NIOSH

# 1986

# Report on Occupational Safety and Health For FY 1986

## Under Public Law 91-596

**U.S. Department of Health and Human Services**
**Public Health Service**
Centers for Disease Control
National Institute for Occupational Safety and Health

# NIOSH REPORT ON OCCUPATIONAL SAFETY AND HEALTH

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# I. INTRODUCTION

## Background

Almost all Americans either work or are dependent on someone who does; therefore, the health of the Nation's workers is vital to the well-being of the country and to the quality of those workers' lives. From early in our history, when hunters first faced the dangers of confronting animals and using weapons, to farming and mining with their accompanying dusts and fumes, and into the industrial revolution with its dangers from machines and toxic exposures, the human family has been subject to hazards while providing for its vital needs. Even recent shifts to service and information jobs in our modern economy involve hazards, such as ergonomic and psychological stresses to the workforce.

Thus, with each advance in society, new occupational hazards have been introduced and added to the hazards still present from past eras. Too often, occupational components have not been recognized as contributing to diseases and injuries; in other cases they have been accepted as inevitable. Because occupational diseases and injuries are a by-product of human endeavor, they are preventable.

## Government Involvement

The United States recognized early in its history the value of workers to the well-being of the Nation. In 1798, the fifth Congress established the first Federal health program, the Marine Hospital Service for merchant seamen. This program later became the U.S. Public Health Service, with responsibilities for the health of all our citizens, but its origins were in occupational health.

The first permanent government agency devoted solely to occupational safety and health was established in 1914 as the Office of Industrial Hygiene and Sanitation. During several organizational and name changes in subsequent decades, this Office built the staff of a federal organization to prevent injury and illness among America's workers. The Occupational Safety and Health Act of 1970 (PL 91–596) transformed the Office, then known as the Bureau of Occupational Safety and Health, into the National Institute for Occupational Safety and Health (NIOSH). NIOSH was placed in the Department of Health, Education, and Welfare (now Health and Human Services) and became the lead Federal agency for research into occupational safety and health problems.

In 1973, NIOSH became part of the Centers for Disease Control (CDC), an arm of the Public Health Service in the Department of Health and Human Services. CDC is responsible for safeguarding the health of all Americans by controlling or preventing disease and injury.

### OSHA: the Regulatory Agency

The 1970 Act also created the Occupational Safety and Health Administration (OSHA) as a regulatory agency and placed it in the Department of Labor. OSHA is responsible for promulgating standards for occupational safety and health, for enforcing those standards, and for investigating any suspected violation of standards. It also provides consultation and training services for employers and employees.

### NIOSH: the Research Agency

NIOSH, by contrast, is a research agency. It has responsibility for protecting the health and safety of America's workers by conducting research and analyzing the results of that research to prevent illness and control hazards in the workplace. NIOSH has other legislative mandates in addition to the Occupational Safety and Health Act; these come under the Federal Mine Safety and Health Act, the Public Health Service Act, the Toxic Substances Control Act, the Clean Air Act, the Outer Continental Shelf Lands Act, and the Comprehensive Environmental Response, Compensation, and Liability Act (Superfund).

Because NIOSH is a scientific research agency, its influence depends on the scientific quality of its findings and recommendations. It is unique among Federal research institutions in its ready response to requests for assistance from employers and employees, and it maintains broad interaction—both nationally and internationally—with other groups and individuals that have similar concerns to help foster a cooperative effort in combating these problems. To help establish priorities, both internally and in its interactions with others, NIOSH has developed a list of ten leading work-related diseases and injuries (Table 1). All the Institute's efforts are directed toward one purpose: the protection and preservation of good health for American workers.

Table 1. Leading Work-Related Diseases and Injuries – United States

1. Occupational Lung Diseases
2. Musculoskeletal Injuries
3. Occupational Cancers
4. Severe Occupational Traumatic Injuries
5. Occupational Cardiovascular Diseases
6. Disorders of Reproduction
7. Neurotoxic Disorders
8. Noise-Induced Hearing Loss
9. Dermatological Conditions
10. Psychological Disorders

## NIOSH Activities

NIOSH is mandated to carry out four basic tasks:

1. To respond to requests for investigations of workplace hazards;

2. To conduct research to identify, evaluate, and control or prevent work-related health and safety problems, including behavioral and motivational factors;

3. To recommend to OSHA and the Mine Safety and Health Administration (MSHA) appropriate regulatory actions based on scientific findings; and

4. To train occupational safety and health professionals to carry out the other mandates of the Act.

These tasks are organized into four program strategies: identification, evaluation, control, and dissemination.

**Identification**: Before action can be taken to reduce or eliminate occupational health and safety hazards, the hazards must first be identified. NIOSH identifies problems in two ways. First, it responds to requests from employers or employees and their representatives for investigations of health and safety hazards in the workplace. Results of these investigations, called Health Hazard Evaluations (HHEs), are made available to all involved and interested parties and to the Department of Labor.

Second, NIOSH conducts surveillance. Although no national or universal system exists for surveillance of occupational safety and health, NIOSH makes use of the data available from the Bureau of Labor Statistics, the Social Security Administration, the National Center for Health Statistics, the National Institute of Environmental Health Sciences, the National Cancer Institute, the National Safety Council, state workers' compensation files, state vital statistics and other state files, hospital discharge data, and the National Electronic Injury Surveillance System. In addition, NIOSH conducts its own surveillance activities, including the National Occupational Exposure Survey (NOES), the National Occupational Hazard Survey (NOHS), the National Study of Coal Workers' Pneumoconiosis, and the National Occupational Health Survey of Mining (NOHSM).

**Evaluation**: NIOSH evaluates work-related health problems to help understand their cause and severity. This is done primarily through targeted laboratory and field research. As an aid to setting priorities and focusing the Institute's activities and resources on the most important problems, NIOSH has developed a suggested list of ten leading work-related diseases and injuries.

The Institute maintains analytical chemistry and biological expertise that supports its laboratory research and field studies. Air and biological samples are analyzed, and new methods are developed for sampling and measuring toxic materials.

**Control**: The ultimate goal of the Institute's prevention program is to control work-related diseases and injuries by discovering, assessing, and improving measures that can reduce occupational hazards. This, too, is accomplished through targeted research in the areas of control technology and personal protective equipment. In the latter category, NIOSH, in conjunction with the Mine Safety and Health Administration (MSHA), tests and certifies respirators based on their compliance with requirements in 30 CFR 11 and 30 CFR 74.

**Dissemination**: To be effective in protecting workers, the results of research must be applied in the workplace. To help accomplish this, NIOSH disseminates its research findings to a wide variety of organizations and persons who are in positions to put them into practice.

- NIOSH makes recommendations for standards and submits them for regulatory action by OSHA and MSHA. These recommendations are produced in the form of Criteria Documents and testimony before the regulatory agencies.

- NIOSH presents its findings at scientific meetings and also publishes *Current Intelligence Bulletins*, the *NIOSH Manual of Analytical Methods*, control technology assessments, hazard alerts, fact sheets, research reports, and articles in scientific journals and the CDC *Morbidity and Mortality Weekly Report.*

- NIOSH conducts training courses in occupational safety and health, supports 14 Educational Resource Centers for training professionals in these fields, and strives through its projects, "Minerva" and "Shape," to incorporate occupational safety and health principles into the curricula of schools of business and engineering, respectively.

- NIOSH maintains a library, several databases, a mailing list of 18,000 professionals (12% from foreign countries), and a publications office to answer questions and to distribute publications on occupational safety and health matters.

- NIOSH provides for data retrieval through NIOSH-TIC and for information from the primary research literature to support occupational safety and health professionals who help protect workers at hazardous waste sites.

**Organization of the Institute**

To address health and safety problems for America's workers, NIOSH coordinates the efforts of a wide variety of trained scientists: physicians, nurses, industrial hygienists, epidemiologists, toxicologists, chemists, physicists, engineers with various specialties, behavioral scientists, ergonomists, psychologists, and sociologists, as well as statisticians, educational specialists, and writers.

The Office of the Director for the Institute is supported by an Office of Program Planning and Evaluation; an Office of Administrative and Management Services; and a Grants Program Activity, all located in the CDC facility in Atlanta, Georgia; and a liaison office maintained in Washington, D.C. The Institute also has seven divisions, two in Morgantown, West Virginia: Division of Safety Research and Division of Respiratory Disease Studies, and five in Cincinnati, Ohio: Division of Biomedical and Behavioral Science, Division of Surveillance, Hazard Evaluations, and Field Studies, Division of Physical Sciences and Engineering, Division of Standards Development and Technology Transfer, and Division of Training and Manpower Development (Figure 1). NIOSH industrial hygienists are assigned to regional offices that serve the U.S. Public Health Service in Atlanta, Boston, and Denver.

**Division of Biomedical and Behavioral Science (DBBS)** This division conducts laboratory experimentation, worksite investigations, and surveys focused on toxicology, stress, ergonomics, and physical agents of health consequence.

The DBBS toxicology program emphasizes (a) testing the carcinogenicity of chemical compounds and materials used in industrial processes, (b) determining other toxic effects expressed by cardiopulmonary, neurologic, reproductive, and dermatologic indicators, and (c) studying substitute materials. Improved, more sensitive techniques are developed for use in research and monitoring activities to detect biological changes.

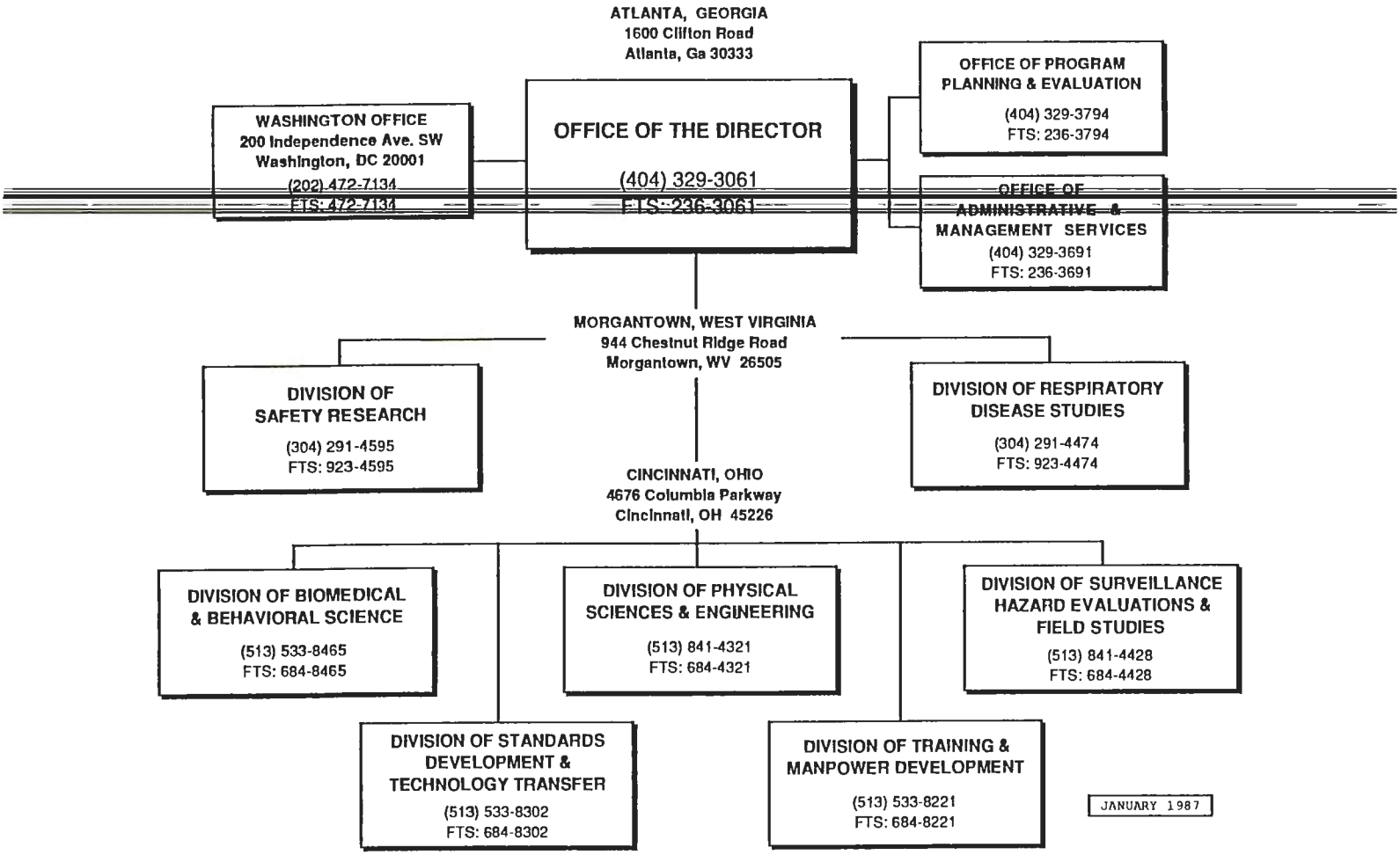
Stress research involves investigating job demands and workplace conditions that produce emotional and mental strains and related psychological disorders. Improved methods to rate job stress/strain and techniques for stress reduction are assessed. Studies focus on worker groups and conditions thought to have the greatest potential for stress/strain problems.

Ergonomics includes developing techniques to limit the overexertion hazards of lifting and to reduce wear-and-tear musculoskeletal injuries of the upper and lower limbs that result from poor tool design, faulty work-station layout, or tasks requiring undue repetitive, forceful movements. DBBS develops and tests guidelines in workplace evaluations to reduce inherent biomechanical stressors and musculoskeletal strain.

Physical agents research concentrates on improving methods to measure and characterize exposures to physical agents in the workplace, such as noise, heat, vibration, and non-ionizing radiation. DBBS also develops and applies techniques in the laboratory to study the biological effects of these agents.

**Division of Physical Sciences and Engineering (DPSE)** This division conducts worksite and laboratory research to control and measure occupational health hazards. To help prevent occupational diseases and injuries before they occur, it identifies and evaluates effective engineering controls and promotes the transfer and widespread application of these controls. It conducts research to establish performance requirements for direct-reading, area and personal sampling instruments and to develop and improve methods for analyzing toxic and carcinogenic substances found in the workplace. The division also helps to form effective workplace standards and to develop criteria and standards for monitoring instruments and controls.

Figure 1. The National Institute for Occupational Safety and Health



To ensure quality control, the Division's Proficiency Analytical Testing (PAT) Program provides reference samples to public and private industrial hygiene laboratories, determines the analytic competence of participating laboratories, and assists laboratories to improve analytic performance. The division also encourages and helps to develop national guidelines for accreditation of industrial hygiene laboratories and selects and develops standard reference materials for measuring industrial hygiene hazards.

DPSE provides analytical chemistry support to the Institute's laboratory research and field investigation programs and provides consultation to other government agencies through the use of state-of-the-art analytic instruments such as high resolution gas chromatography, gas chromatography-mass spectrometry, high performance liquid and ion chromatography, plasma emission spectroscopy, and Fourier Transform Infrared Spectroscopy, and, when necessary, through the development of new analytic methods.

**Division of Respiratory Diseases Studies (DRDS)**: This division provides legislatively mandated medical and autopsy services and conducts clinical and epidemiologic research on occupational respiratory diseases. It carries out field studies, designs and interprets cross-sectional prospective morbidity and mortality studies, and uses epidemiologic techniques to detect common characteristics of occupational respiratory diseases. The division also conducts cell biology research to identify factors involved in the early detection and differential rates of susceptibility to occupational respiratory diseases and to elucidate the effects of environmental exposure on immunologic mechanisms associated with these diseases.

DRDS provides for medical examinations mandated under the Federal Mine Safety and Health Amendments Act of 1977 and operates a certification program for medical facilities and physicians who participate in these examinations. It evaluates and approves employer programs for examining workers in accordance with published regulations and arranges for examinations of employees who work where no examination program is approved. The division also conducts the National Coal Workers' Autopsy Program, provides autopsy evaluations and a pathology research program, and studies the post-mortem identification and measurement of occupational respiratory exposures.

**Division of Safety Research (DSR)**: This division is the focus of the Institute's occupational safety research program. It designs and conducts research to prevent or mitigate the traumatic injury and death of workers in all but the mining industry. It also plans and conducts laboratory and worksite studies to make work safe through engineering controls and through personal protective equipment. For example, the division conducts worksite research to identify, develop, and document effective work practices and managerial approaches that minimize the risk of injury; provides technical assistance in solving safety problems that require engineering or system safety expertise; and develops technical criteria to support recommendations for safety standards. The division also evaluates, certifies, and maintains records of respirators and hazard measuring instruments and develops new performance criteria, standards, and guidelines for certification of these devices. It is responsible for the day-to-day testing and certification of respirators (30 CFR 11) and coal-mine-dust personal sampling units (30 CFR 74).

DSR collects, analyzes, and interprets injury statistics for general occupational injury surveillance and maintains a national surveillance data system for the early detection and monitoring of occupational accidents and injuries. It assists State agencies to upgrade injury surveillance and maintains a national injury surveillance system for risk assessment to help identify problems and to set priorities for research. The division conducts field epidemiologic studies of occupational injuries and their etiologies and studies the occurrence and extent of accidents and injuries in occupational settings. To help reduce musculoskeletal injuries, DSR characterizes the effects of the workplace environment on safety and provides technical assistance in ergonomics, industrial engineering, and related disciplines.

**Division of Standards Development and Technology Transfer (DSDTT)**: Using existing scientific and technical information, this division develops documents that contain (a) criteria for recommended occupational safety and health standards, and (b) technical and scientific information for a variety of occupational safety and health issues. It also coordinates NIOSH testimony for recommended standards to control occupational safety and health hazards at hearings held by the Department of Labor (DOL) on proposed standards. Criteria Documents prepared by the division to recommend standards to DOL include environmental limits, safe work practices, sanitation, monitoring, labeling, recordkeeping requirements, medical examinations of workers, personal protective equipment and clothing, and employee notification of hazards.

Through liaison with government and non-government sources, DSDTT obtains technical data and develops

and maintains several technically oriented computer databases. It manages a clearinghouse for receiving, storing, retrieving, and disseminating technical information on occupational safety and health; maintains the mailing of more than 18,000 industrial hygienists, health care providers, safety professionals, and librarians and other information specialists for distributing occupational safety and health information; and prepares reviews of occupational hazards and risk assessments of potential workplace hazards.

DSDTT identifies information on worker exposure and the severity of chemical hazards through the development of profiles and, to identify potential workplace hazards quickly, maintains a system for determining the status of projects in other federal agencies and the private sector. It revises annually the legislatively mandated list of toxic substances.

**Division of Surveillance, Hazard Evaluations, and Field Studies (DSHEFS):** This division conducts surveillance of the Nation's work force and its environs for early detection and continuous assessment of the magnitude and extent of job-related illnesses, exposures, and hazardous agents. To do this, it uses existing data sources and helps to develop new data sources in federal, state, and local agencies, and with labor, industry, tumor registries, physicians, and medical centers. It also evaluates and validates studies of reporting systems for occupational illness to help measure the national occupational health problem.

DSHEFS conducts legislatively mandated health hazard evaluations and industrywide epidemiologic research programs through longitudinal record studies, clinical/environmental field studies, and surveys. On request and on a self-initiated basis, it also provides technical assistance, demonstrations, and consultations on technical occupational safety and health matters to other federal agencies, State and local agencies, and to technical groups, employers, unions, and employees.

**Division of Training and Manpower Development (DTMD):**7 This division carries out the mandated training and education functions of the Institute to increase the numbers and competence of occupational safety and health professionals and paraprofessionals in the country. Through the continuing education program, it provides short-term technical training courses to federal, State, and local government, private industry, labor unions, and other organizations in the field; these include seminars, independent study packages, and specialized workshops. The division supervises the 14 Educational Resource Centers and training project grants at universities throughout the country, designs curricula, and produces course packages and training materials for Institute-sponsored training programs that are presented by in-house faculty and by universities and other outside training organizations.

Through its educational resource development program, DTMD continually assesses the need for occupational safety and health practitioners and researchers nationwide. To help meet this need, it administers a major training-grant program to develop academically based training for occupational physicians, occupational health nurses, industrial hygienists, toxicologists, epidemiologists, and safety professionals, including engineers and managers.

**Grants Program Activity:** This office advises the Institute on the development and progress of NIOSH-sponsored extramural research; cooperates with the Institute's divisions and offices to stimulate grant applications for research and demonstration projects in relevant priority areas; monitors in-depth reviews from consultant experts of grant proposals; conducts secondary reviews of grant proposals; receives and evaluates reports of grant-supported projects; and coordinates the grants program with the Institute's intramural and contract research and with related programs in other HHS units, U.S. Department of Labor, U.S. Department of the Interior, and other agencies.

## Highlights of the NIOSH Program for Fiscal Year (FY) 1986

NIOSH operated in FY 1986 with 798 budgeted full-time equivalents and appropriated funds of $64.551 million, of which $6.221 million was allocated for research grants and $8.383 million for training grants. Currently, 15 officers from the CDC Epidemic Intelligence Service (EIS) are assigned to NIOSH. A few highlights from the FY 1986 activities are summarized below.

- Conducted 501 site visits and completed 618 health hazard evaluations, compared with 553 evaluations in FY 1985. NIOSH evaluated the possible hazards of chemical, biological, or physical agents used or found in the workplace and recommended control procedures, improved work practices and medical screening to reduce exposure levels and subsequent health effects.

- Completed 53 Fatal Accident Circumstances and Epidemiology evaluations as part of the NIOSH program to identify risk factors and develop intervention strategies for preventing fatal occupational accidents.

- Continued the National Occupational Health Survey of Mining (NOHSM); 254 surveys representing 33 commodities have been completed to date. This activity will record the presence and use of all potentially hazardous substances at mining facilities in the United States and will supply MSHA with information for setting standards, improving compliance with existing standards, and identifying research needs and priorities.

- Continued action as the lead agency for tracking the 1990 Objectives for the Nation in occupational safety and health.

- Worked with 14 hospitals that participate in the National Electronic Injury Surveillance System (NEISS) to assist them in coding industry and occupation for the occupational injuries treated in their emergency rooms. With detailed causal information from follow-up surveys of the injury victims, national estimates of specific categories of occupational injuries will be possible and specific industries and occupation can be targeted for safety intervention research. Twelve monthly reports summarizing NEISS data were completed and distributed.

- Continued analysis of data from 1979–1980 on acute work-related conditions and also prepared a report on workers' perceptions of occupational risks and potential health consequences in 1985. The latter will be used to target employment groups for health promotion/education and to identify risks not previously documented.

- Provided training to state health department personnel for coding information on the industry and occupation of decedents. In FY 1986, 40 persons from 17 State and local health departments were trained. Since inception of the program in 1981, 186 individuals from 36 State, local and territorial health departments have been trained.

- Continued Project Shape (Safety and Health Awareness in Preventive Engineering). Results were: (1) completion of an occupational safety and health engineering text entitled "Engineering Control of Workplace Hazards;" (2) completion of the Accreditation Board for Engineering and Technology (ABET) study of the safety and health content of accredited engineering academic programs; (3) successful operation of a pilot engineering speaker's bureau with six presentation at engineering society student chapter meetings; (4) completion of the teaching institute at American Society for Engineering Education (ASEE) annual conference; (5) completion of the Advanced Industrial Hygiene Engineering Course Manual; (6) completion of a series of seven engineering case studies; (7) issuance of research grant program supplement entitled "Engineering Control Systems Research."

- Continued follow-up of research leads in occupational cancers identified from computer-generated maps. One such study showed an elevated rate of non-Hodgkin's lymphoma among farmers and is consistent with other studies linking farming and malignant lymphomas. NIOSH is compiling information to publish a bulletin that will alert the farming community to this potential hazard.

- Convened a workshop for representatives from the Conference of State and Territorial Epidemiologists and other interested persons to encourage state-based reporting of morbidity from occupational diseases. A proposed surveillance system for silicosis, asbestosis, and coal workers' pneumoconiosis and the diagnostic and reporting criteria were discussed.

- Correlated Bureau of Labor Statistics (BLS) and workers' compensation claim data on dermatologic conditions resulting from occupational exposures. After analyzing these data, three major industries —agriculture, manufacturing, and construction— were identified with the highest rates of skin disease.

- Conducted histopathological reviews of 3,400 autopsy reports from 27 states received by the National Coal Workers' Autopsy Study for 1971–1980. The results showed a high prevalence of silicosis in a miner population that was relatively disease-free during life. Thus, previous studies of silicosis in coal workers may have underestimated the incidence of this disease.

- Expanded pneumoconiosis studies to include not only underground coal miners but also surface coal miners. Results from examining 1,000 surface-anthracite miners and classifying their radiographs show a significant increase in pneumoconiosis among drillers at surface mines.

- Assessed the contribution of job-task variables and personal factors to the development of cumulative trauma disorders of the upper extremities. Results to date indicate that workers in jobs with both high-force requirements and high-repetition rates have 30 times the likelihood of developing hand/

wrist disorders as those in low-force/low-repetition jobs.

- Conducted a study of garment workers, which found evidence of a possible relationship between exposure to formaldehyde and the development of upper respiratory cancers, leukemias, and other lymphopoietic neoplasms.

- Conducted a follow-up study of workers exposed to polychlorinated biphenyls (PCBs) and found a statistically significant excess of deaths from cancer of the liver and biliary passages. PCBs have been shown to cause liver tumors in laboratory animals.

- Conducted a study of bridge and tunnel officers, which suggests that carbon monoxide may play an important role in the pathophysiology of cardiovascular mortality. This agrees with other evidence that carbon monoxide is the factor in cigarette smoke associated with cardiovascular mortality.

- Presented 26 occupational safety and health courses to professional trainees, including personnel from the private sector and local, State, and federal agencies.

- Conducted a study of men exposed to ethylene dibromide (EDB) in six fumigation plants, which strongly suggests that EDB may increase the risk of reproductive impairment of workers at levels near the NIOSH recommended exposure limit and below the current OSHA standard for EDB.

- Continued studies on violent deaths in the workplace, which revealed an increasing number of deaths from excavation cave-ins; an especially high risk of homicide among women working in gasoline service stations, eating/drinking establishments, and food/bakery/dairy stores; and the highest rate of fatal injury to be among drivers of heavy trucks.

- Provided 310 continuing education courses through the Educational Resource Centers (ERCs), for occupational health nurses, occupational health physicians, industrial hygienists, safety professionals and others responsible for worker protection. In the 1985–1986 school year, 1,030 full-time students were enrolled in ERCs and other training grant programs, 388 students took professional preparations on a part-time basis, and 1,879 students from other disciplines took one or more occupational safety and health courses as electives. In the ERC program alone, 597 students were enrolled full-time.

- Added eight new schools of business to the Project Minerva program (integrate occupational safety and health management concepts and principles into the curricula of business schools), making the total 37. Enrolled an estimated 2,500 prospective managers in academic courses incorporating occupational safety and health topics. Convened the annual Project Minerva Workshop, bringing together representatives from industry, labor, government, and academia. Developed instructional resources, including two instructional modules, a book of safety and health journal readings, management oriented videotapes and a faculty resource guide entitled "Safety and Health Research Topics for Business Students."

- Revised and updated NIOSH courses based on changes in the published OSHA standards. Some examples are: Sampling and Evaluating Airborne Asbestos Dust, Occupational Respiratory Protection, and Confined Workspaces. A series of lecture modules reflects the national strategies for the first five of the "Ten Leading Work-Related Diseases and Injuries."

- Developed short-term methods in response to requests for evaluations of such substances as oxydianiline, benzophenone tetracarboxylic acid dianhydride, tallowamine, diethylthiophosphate in urine, and aspartame. Industrial hygienists use these methods and sample analyses to make recommendations where necessary for reducing or eliminating exposures and providing a safer work environment.

- Completed a laboratory system (including equipment and instrumentation setup and software development) to continuously monitor human subject physiological responses and the performance of self-contained breathing apparatus (SCBA) during actual "simulated" conditions. This laboratory system will eventually replace antiquated methods currently used for performing human subject testing of SCBA and will be proposed for use in the NIOSH Respirator Testing and Certification Program under 30 CFR Part 11.

- Published a sampling and analytical method for fibers (Method 7400) in the third edition of the *NIOSH Manual of Analytical Methods*. Prepared 50 revised methods, including new and revised methods for asbestos, for inclusion in the second Supplement to the *Manual*.

- Conducted a study of male workers at a precision metal parts company, which suggests a possible effect of 2-ethoxyethanol (2EE) on sperm count.

- Prepared an article on "Silicosis Surveillance: Worker's Compensation Data, 1979–1983," concluding that reduction in cases of silicosis reported to the Bureau of Labor Statistics, Supplementary Data Systems, might be possible by developing and testing model intervention programs in up to six states (Colorado, Kentucky, New York, North Carolina, Ohio, and Wisconsin) with emphasis on mining, primary metal, stone, clay, and glass industries, and on laborers and machine operators with non-specific job titles.

- Conducted a 3-day workshop during which stress measurement methods were evaluated. Developed a generic job stress/strain assessment tool for use in evaluating stress/strain across occupations. Based on workshop deliberations, two promising methods of stress assessment were chosen for evaluation/validation in FY 1987.

- Developed a safety system consisting of optical, ultrasonic, and pressure-sensitive sensors and interfaced with a laboratory robot to demonstrate a complete system for safeguarding a robotic work envelope. Also, initiated a study aimed at refining the signal processing, antenna design, and bridge and circuitry development of capacitance sensor to improve accuracy in detecting human position in relation to a robot manipulator.

- Filled 24,500 requests for publications. NIOSH-developed databases extend access to occupational health information throughout the United States and in foreign countries. The data-systems include the Current Research File, the Document Information Directory System, the Priorities Research Analysis Tracking File, the Translation Information System, and the NIOSH mailing list.

- Validated a portable test battery to determine fatigue during a laboratory simulation of 12-hour work days. Decrements in performance and alertness associated with long hours of work were apparent in several tasks. The test battery was also administered to a sample of operators at a nuclear power plant to ascertain the fatigue effects of converting from an 8-hour to a 12-hour rotating shift schedule. A report of the worksite study was completed, documenting less efficient test performance and reduced alertness under the 12-hour shift schedule.

- Validated a biological monitoring method to assess worker exposure to coal tar pitch. Also studied the cocarcinogenic activity of asphalt fumes by controlled generation of fumes and then separation, chemical characterization, and bioassay of the principal fractions by painting them on the skin of experimental animals. Although components of asphalt fumes have been shown to cause cancer, no methods have been developed to date to protect the 116,000 exposed workers.

- Submitted a report to MSHA on trends in coal mine dust exposures for the years 1981–1985, with analyses based on mining occupations, mining methods, and geographic location of the mines. The report indicated relatively high exposures related to longwall mining.

- Developed, modified, and tested a prototype direct-reading monitor for measuring ammonia that will provide immediate feedback to both worker and employee on the extent of exposure. A monitor and the corresponding technology can be used to measure contaminant exposure in the breathing zone of workers.

- Continued 16 of the 17 original cooperative agreements for building surveillance capacity within the states. In this third year of the program, all participants now have some degree of surveillance capability, and each has now developed some intervention capacity. Five agreements, funded jointly by NIOSH and the CDC Center for Environmental Health, focus on public health problems with both occupational and environmental components.

- Awarded grants in the following program areas: 17 for occupational lung diseases; 4 for musculoskeletal injuries; 7 for occupational cancers; 2 for severe occupational traumatic injuries; 9 for reproductive disorders; 8 for neurotoxic disorders; 5 for occupational noise-induced hearing loss; 4 for dermatologic conditions; 3 for psychological disorders; 4 for engineering control systems; 4 for respirator research; and 13 for other occupational health problems.

**Additional Facts and Figures**

- Processed 5,250 chest radiographs for coal miners in the X-ray surveillance program.

- Processed 267 autopsies for coal miners.

- Processed 12,000 industrial hygiene samples.

- Issued 361 certification decisions for respirators (approvals, extensions, and denials).

- Published 3 Current Intelligence Bulletins: methylene chloride, polychlorinated biphenyls (PCBs), and 4,4'-methylene dianiline.

- Published 1 Criteria Document: occupational exposure to hot environments.

- Published 3 Alerts: confined spaces, grain auger electrocutions, and fatalities due to oxygen-limiting silos.

- Published 17 articles in the CDC *Morbidity and Mortality Weekly Report* and 153 articles in peer-reviewed scientific journals.

- Developed 12 new sampling/analytical methods.

- Evaluated 760 laboratories performing metal, organic, silica, and asbestos analyses.

# II. PROGRAM STRATEGIES

## A. Identification

The identification of occupational diseases and injuries is an important first step in planning programs to combat them. If prevention strategies are to be formulated, adverse health and safety conditions must be recognized and the occupations and population groups affected must be located To assure the most efficient use of resources, the relative importance of a wide variety of work-related diseases and injuries must be determined. And, finally, as prevention strategies are implemented, progress in combating these adverse health conditions must be measured. A national surveillance system or universal state system to adequately address these needs is not presently available in the United States. The systems that do exist, while providing some work-related data, were designed for other purposes and cover only limited aspects of the field. Thus, a high priority at NIOSH is adapting current surveillance systems and developing new systems to bridge gaps and correct deficiencies in information.

### 1. Surveillance

**NOHS and NOES**

NIOSH continues to compile and analyze data obtained in two large-scale probability samples of potential exposures in general industry workplaces. The National Occupational Hazard Survey (NOHS) (1972–1974) and the National Occupational Exposure Survey (NOES) (1981–1983) sought to define (a) the types of industries where potential hazards are found, (b) the occupational groups where workers are exposed to such hazards, and (c) the chemical components of tradename products found in the workplace. These surveys constitute the centerpiece of the Institute's hazard surveillance research program for general industry. Conducted a decade apart, they present an opportunity to monitor the impact of the Occupational Safety and Health Act of 1970. As analysis of the data proceeds, information will be released periodically over the next 5 years, and the data will be available for NIOSH research and for other government agencies, occupational health research specialists, workers and their representatives, and health care providers. Currently, NIOSH responds annually to several hundred requests from a wide variety of users for information already in the NOHS and NOES databases.

Information from these surveys is now being analyzed in a variety of ways.

- The NOHS database has been reformatted as a job-exposure matrix (JEM) to enhance its use in epidemiologic investigations. The JEM is now being adapted for microcomputers to make it available to a wider spectrum of users.

- Computer-generated maps show the state and county distribution of plant sites or worker populations where potential occupational exposures are thought to occur. These maps can be developed for single agents (e.g., silica, ethylene oxide) or families of chemical agents with similar health effects.

- Survey data are being linked to information in the NIOSH Registry of Toxic Effects of Chemical Substances (RTECS) to help identify industries and occupations at high risk of exposures to toxic compounds.

- Because substances with similar chemical structures usually have similar chemical reactivity, a structure-activity technique is being used to predict the potential toxicity of chemicals for which no experimental information on their toxicity exists.

- The potential hazard of exposure to tradename products cannot be determined until the ingredients of these products are known. More than 100,000 tradename products were recorded during NOES, and NIOSH is currently requesting component information from respective product manufacturers. Approximately 35% of the products recorded have now been sent out for clarification, and nearly 15,000 have already been resolved.

- Technical reports were completed this year and are being prepared for publication describing the procedures used for gathering data during the field phase of the surveys, the strategy used to select establishments for the survey, techniques for expanding survey data to national statistics, and detailed analysis of the approximately 60 questions administered at each establishment.

**National Occupational Health Survey of Mining**
The Mine Safety and Health Administration (MSHA) has asked NIOSH to identify potential exposures to all health-related agents in the mining industry, including chemicals, tradename substances, physical agents and musculoskeletal conditions. Begun in 1984, this National Occupational Health Survey of Mining (NOHSM) will not only identify potential exposures but will also provide information necessary for preventing exposure-related diseases and injuries. MSHA will use this information to improve its direct enforcement activities, to identify needs for new health standards, and to identify areas that require additional research. Representative mines in several product or "commodity" groups are selected for survey. A report submitted to MSHA in the fourth quarter of FY 1986 covered potential exposures in facilities that mine the commodity, beryl. By the end of FY 1986, NIOSH had completed 254 NOHSM surveys representing 33 commodities. The field phase of the study is now scheduled for completion in FY 1989.

**National Study of Coal Workers' Pneumoconiosis**
To facilitate early detection of coal workers' pneumoconiosis, NIOSH administers periodic chest X-rays to coal miners. If evidence of disease is found, the workers may transfer to work areas with lower dust levels. In FY 1986, a comprehensive report was compiled summarizing radiographic information for 1970 to the present from both a national research study and the surveillance program for coal miners. The information was compared with data published before 1970, and preliminary findings indicate that current standards for respirable coal mine dust are appropriate and effective in controlling the onset and progression of CWP. Confirmation of these results must await longer, comprehensive follow-up.

**Fatal Accident Circumstances and Epidemiology**
To help identify risk factors that contribute to occupational fatalities and injuries, NIOSH is studying the hazards of electrical energy, confined spaces, and excavations through its project on Fatal Accident Circumstances and Epidemiology (FACE). In FY 1986, the Institute conducted 53 field evaluations; added Maryland, South Carolina, and Virginia to the participating states, bringing the total to 10; published three Alerts and drafted six others; and developed draft protocols for research on electrical and confined-space fatalities. Preliminary data suggesting lack of training as a factor contributing to fatalities have influenced the incorporation of training requirements into OSHA standards. Several NIOSH Alerts have been republished and distributed by states, insurers, and other government and private organizations.

**Injury Surveillance**
NIOSH continues to receive data from the National Electronic Injury Surveillance System (NEISS) on occupational injuries by age and sex of the victim, nature and source of injury, type of accident, and body part injured. In FY 1986, information on industry and occupation was also recorded for 14 hospitals and will be recorded for all NEISS hospitals beginning in FY 1987. Through NEISS, NIOSH can locate victims of specific types of occupational accidents and can obtain further information on the circumstances of the injury. The Institute completed and distributed 12 monthly reports summarizing NEISS data in FY 1986.

NIOSH is continually adapting and improving other data systems to better identify and describe populations with high rates of occupational injury. In FY 1986, new databases were acquired and existing databases—such as MSHA, SDS, and County Business Patterns—were updated. Technical assistance to the Industrial Commission of Ohio resulted in the first chapter of a monograph on lockout-tagout safety mechanisms. Operational statewide injury-surveillance systems grew out of cooperative agreements with state agencies in Colorado, North Dakota, and Utah, to name a few such activities.

As an aid to setting priorities in research and intervention for occupational injuries, NIOSH used five factors to identify the most hazardous industries: 1) incidence rate for all occupational injuries, 2) incidence rate for lost workdays, 3) number of lost workdays per 100 workers, 4) workers' compensation fatality ratio, and 5) employment. Based on these criteria, the top five industries are lumber and wood products; trucking and warehousing; food and kindred products; special trades construction; and stone, clay, and glass. The top five occupations in each of these industries were also identified and data from the BLS Annual Survey for 1972–1983 were used to create a pilot national safety regression model from which research priorities can be set.

**Computer-Generated Maps**
Computer-generated maps, showing locations with a high potential for exposure to specific occupational hazards or a high incidence of work-related disease or injury, are used to identify research leads. In FY 1986, such leads involved the study of stomach cancer and peptic ulcer in Rhode Island, cancer of the kidney in Maine, cancer of the pancreas in Massachusetts, and lymphomas in Ohio. The Ohio study showed an elevated rate of non-Hodgkin's lymphoma among farmers and is consistent with other studies linking farming and malignant lymphomas. NIOSH is

now taking steps to alert the farming community to this potential hazard.

**Adaptation of Existing Data Systems**
NIOSH makes extensive use of existing health data systems to obtain information on occupational safety and health.

**National Center for Health Statistics**: The National Center for Health Statistics (NCHS) conducts the Health Interview Survey (HIS) annually to obtain health information from 40,000 households representing approximately 115,000 persons. This year, NIOSH continued analysis of HIS data from 1979–1980 on acute work-related conditions and also prepared a report on workers' perceptions of occupational risks and potential health consequences in 1985. The latter will be used to target employment groups for health promotion/education and to identify risks not previously documented.

NIOSH recommended that the NCHS include hearing examinations in the NHANES III survey, submitted a questionnaire to the NHANES study for establishing a history of hearing and noise exposure, and obtained and prepared for dissemination a computer tape of audiograms from industrial hearing-conservation programs.

**Bureau of Labor Statistics**: NIOSH analysis of figures from the Bureau of Labor Statistics (BLS) Supplementary Data System for 1981 showed that the major industries with the highest rates of skin disease are agriculture, manufacturing, and construction. This corresponds well with rankings generated from the 1981 Annual Survey. These industries can now be targeted for prevention and control.

To help correct deficiencies in data on the extent and source of hearing loss induced by occupational exposure, NIOSH has requested that BLS report standard threshold shifts in hearing on the OSHA 200 log. This should provide much needed data on hearing sensitivity for comparing exposed and non-exposed populations.

**Social Security Disability Data**: Although the Social Security Administration (SSA) each day declares about 1,500 workers permanently disabled, the number of disabilities that are work-related is not known. However, NIOSH can use SSA disability data to monitor unusual patterns of disability among U.S. workers in various industry and occupation groups. In FY 1986, NIOSH published two reports on the occupational characteristics of disabled workers for 1975–1976 and the industry and disabling conditions of disabled workers for the same period.

Social Security Disability data hold potential for continuing surveillance of the nature and magnitude of occupational psychological disorders and for targeting occupational risk factors and occupations at risk. NIOSH scientists and Social Security staff met in 1986 and took important first steps in using this database, including analyzing factors that are potential sources of bias in surveillance applications (e.g., occupational differentials in awareness of the Social Security Disability program).

**Mortality Data**: Death certificates are potential sources of information about the cause of death, the industry, and the occupation of the decedent. To help improve the quality and consistency of information on death certificates, NIOSH, NCHS, and the Association for Vital Records and Health Statistics negotiated an agreement to reimburse state health departments for costs incurred in coding industry/occupational information from death certificates. As a result, seven states (Georgia, Kansas, Kentucky, South Carolina, Utah, Vermont, and Wisconsin) supplied data for 1986 on occupationally related mortality. These data will be used collectively by NIOSH, NCHS, and the National Cancer Institute.

NIOSH and NCHS also continued to support a program of training state health department personnel in coding information on the industry and occupation of decedents. Since its inception in 1981, this program has trained 185 individuals from 36 state, local, and territorial health departments. In FY 1986, 40 persons from 17 state and local health departments were trained.

National estimates of work-related deaths are usually unreliable because of variations in procedures of the estimating organizations. To establish a more precise count of occupational deaths, NIOSH is acquiring death certificates from each state and territorial health agency for victims of work-related trauma in 1980–1985. In FY 1986, 34,557 certificates were added to the 3,000 previously in the file. Preliminary analysis has identified on-the-job homicides as a surprisingly large component of occupational fatalities, and future research efforts will be directed to a study of this phenomenon.

A review of death certificates in Texas revealed an increasing number of deaths from excavation cave-ins over the period 1976–1985. The Dallas-Fort Worth and Houston metropolitan areas accounted for 45% of the fatalities, and 80% took place during construction activities.

Further review of death certificates in Texas identified 348 cases of fatal occupational injuries to civilian females in 1975–1984. Homicides caused 53% of the fatalities and motor vehicles, 26%. Women working in gasoline service stations, food/bakery/dairy stores, and eating/drinking establishments had an especially high risk of homicide while the drivers of heavy trucks suffered the highest rate of fatal injury.

**City directories:** Using city directories as a source of occupational and employer information, NIOSH studied mortality among males due to bladder cancer in Hamilton County, Ohio, for the years 1960–1982. Agreement with data from Social Security Earnings reports was about 76%. The directories permitted identification of five companies with excess risk of bladder cancer among employees, whereas death certificates, which list type of industry rather than specific company name, would have permitted identification of only one. The directories, however, only provide data for the years of residence in a particular city.

**Workers' Compensation Claims:** Analysis of data from the Supplementary Data System identified nursing aides and orderlies as having the highest incidence of workers' compensation claims for back sprains or strains. NIOSH has also confirmed the association of back injury with frequency of patient lifts. A contract study is now under way to determine the best equipment and techniques for handling patients.

A review of workers' compensation claims in Ohio for sexual assault in the workplace (1983–1985) showed that 62% of the rapes committed after dark by an unknown assailant occurred in convenience food stores. This corroborates police reports in Memphis, Tennessee, for 1985 and identifies a new area for the development of prevention strategies.

Workers' compensation data from 23 states for 1983 showed that cold injury to the skin most frequently occurred in agriculture, oil and gas extraction, trucking and warehousing, protective services, and interurban transportation. Frostbite injuries to the lower extremities occurred at milder temperatures and lower wind speeds than had previously been found. This indicates the need for greater protective measures in these industries.

**Data from Labor and Trade Associations:** With input from labor and trade associations, NIOSH has completed a study to identify high risk activities in each of four occupations within the construction industry: carpenters, plumber/pipefitters, structural metal craftsmen, and heavy equipment operators. Two new projects have been initiated from this study: an acceptable coefficient of friction to prevent falls from painted structural steel and injury hazards faced by dozer operators. In addition, the Bureau of Labor Statistics is conducting a survey of work injuries associated with heavy construction equipment, using a questionnaire developed by NIOSH.

**State Surveillance Activities**

NIOSH provides state health departments with oversight and technical assistance to develop state-based programs of surveillance for occupational health. Sixteen of the 17 agreements, originally signed in 1984 for building surveillance capacity within states, continued in FY 1986, with two receiving a no-cost extension through December 1986. In the first years, each project built surveillance capabilities and now—in the third year—each has some degree of capability, and each has developed some intervention capacity. Five of the remaining agreements are jointly funded by NIOSH and the CDC Center for Environmental Health and focus on public health problems that are both occupational and environmental.

Through the Surveillance Cooperative Agreements between NIOSH and States (SCANS), five states (Maine, New York, North Carolina, Pennsylvania, and Rhode Island) are now receiving aid for building surveillance capacity. In FY 1986, presentations on surveillance were released by several of these states: Rhode Island activities identified elevated cause-specific mortality from malignant melanoma among white males in the printing industry; a NIOSH presentation at a NCI, EPA, and NIOSH Collaborative Workshop showed how to identify research leads through surveillance when associations are found between site-specific cancers and industrial and occupational subgroups; and finally, a presentation at the World Health Organization Consultation in Copenhagen in November 1985 detailed the value of linking morbidity and occupational exposure data.

This year NIOSH also developed and distributed computer software to the states for editing industry/occupation data and for analyzing sentinel health events (occupational). A workshop was again held for participating states to discuss technical issues of surveillance capacity.

NIOSH convened a workshop in FY 1986 for representatives from the Conference of State and Territorial Epidemiologists and other interested persons to encourage state-based reporting of morbidity from occupational diseases. They discussed a proposed surveillance system for silicosis, asbestosis, and coal workers'

pneumoconiosis and the diagnostic and reporting criteria that must be considered for these diseases.

Through cooperation with NIOSH, two states have instituted surveillance programs for occupational exposures that result in excessive blood lead levels. Lead is known to cause adverse health effects, particularly on the nervous system, and occupational exposures to this substance can be controlled. Working with NIOSH, the Industrial Commission of Ohio has studied lead poisoning cases reported to the workers' compensation system and has successfully demonstrated the value of this data source for surveillance. In Texas, NIOSH representatives helped to frame and encourage passage of the new Texas Occupational Disease Reporting Law. This law is patterned on procedures for the reporting of communicable diseases in Texas and requires physicians and laboratories to report all blood lead tests equal to or greater than 40 ug/dl in persons 15 years and older. Through case follow-up, the extent of the problem in Texas can be ascertained and appropriate preventive measures can be stimulated.

In collaboration with the New York City office of vital statistics, NIOSH continued to evaluate relationships for the years 1978–1982 between parental employment and selected outcomes of reproduction (e.g., spontaneous abortions, congenital malformations, and low birth weight).

NIOSH is supporting population-based cancer registries through a cooperative agreement with the Massachusetts Department of Public Health and through its Research Grants Program in Detroit, Michigan. The Detroit program is also studying employment relationships for workers with newly diagnosed cancer of the colon, rectum, lung, bladder, liver, salivary glands, and eye.

## 2. Health Hazard Evaluation

Employees and their representatives, employers, and Federal, state, and local agencies may request help from NIOSH through the Health Hazard Evaluation (HHE) Program. These requests stem from a need for technical assistance or hazard evaluation for workplace health problems, such as chemical, biological, or physical agents used or found in the workplace. NIOSH also recommends control procedures, improved work practices, and medical screening to reduce exposure levels and the health effects that result from them. In FY 1986, 544 general industry requests were received and 16 requests for mining HHEs (Figures 2 and 3, Table 2). In responding to these and previous requests, NIOSH conducted 501 site visits and completed 618 Health Hazard Evaluation and Technical Assistance (HETA) studies (compared with 553 HETAs in FY 1985). The response time by letter was 1–3 months and for full reports, 7–18 months. Requests for information on asbestos, PCBs, heat stress, respirator use, indoor air quality, and similar topics totaled 178 in FY 1986.

A major effort of the program is to work more closely with state health departments in such areas as 1) participation of state-based EIS officers and other health department personnel in field evaluations, 2) increased dissemination of information to the state health departments, and 3) using cooperative agreements to help states conduct HHEs. Such cooperative agreements were in operation with Iowa, New Jersey, and Rhode Island in FY 1986.

The topics of some evaluations and activities conducted under the HHE program in FY 1986 are given below.

**Occupational lung diseases**

- upper-respiratory symptoms of shipyard employees following exposure to magnesium silicates, Portland cement, and fibrous glass
- a potential respiratory hazard from exposure to cobalt for workers who sharpen and repair carbon steel and tungsten carbide tools
- two employees with severe obstructive lung disease after working in the mixing room of a bakery
- employees in an electroplating facility who developed excessive mucous membrane irritation related to perchloroethylene exposures
- workers with asthmatic reactions following exposure to methyl diisocyanate while insulating the external fuel tank on the space shuttle
- asthmatic reactions of workers exposed to egg protein while producing powdered eggs
- abnormal chest X-rays of workers exposed to asbestos in a petroleum refinery
- exposure to gilsonite, a coal composed of extremely fine particles
- miners exposed to the antifreeze compounds that are sprayed on coal
- asbestos exposures in the mining industry

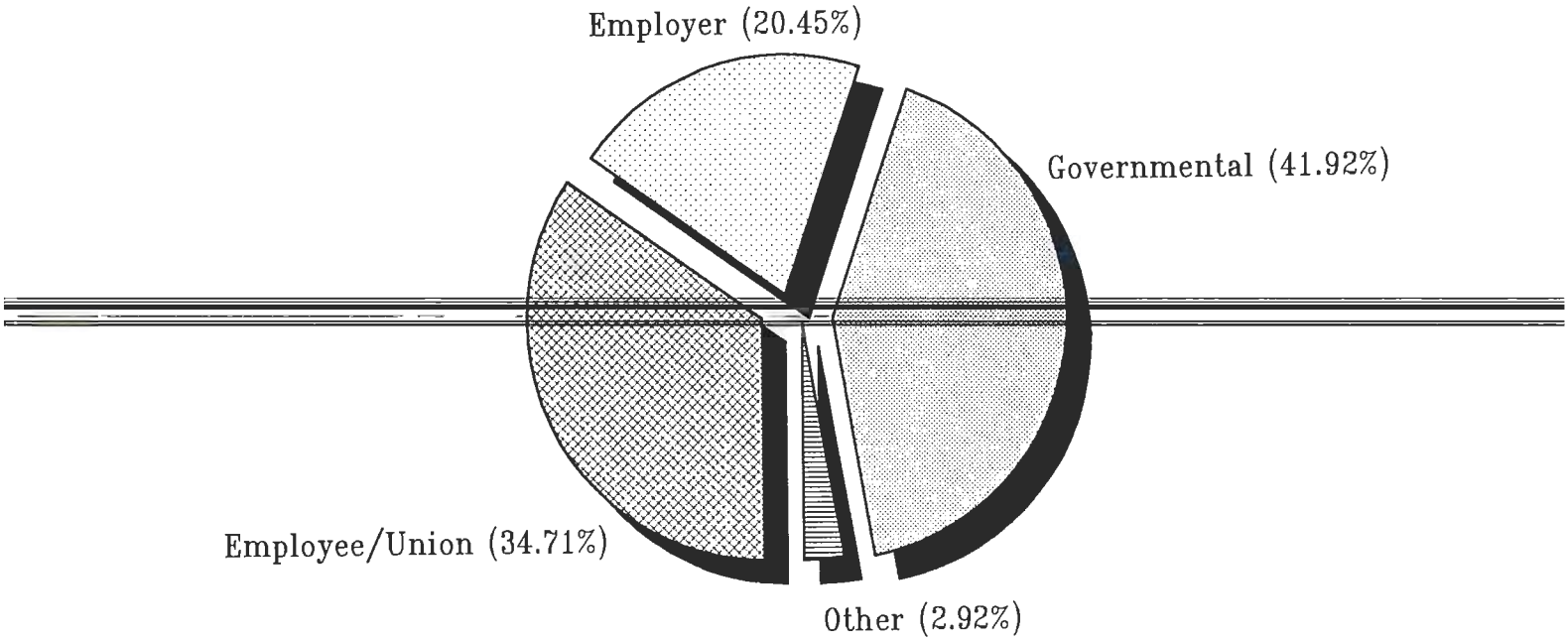



Figure 2 – FY 1985 HETA Requests by Requestor.

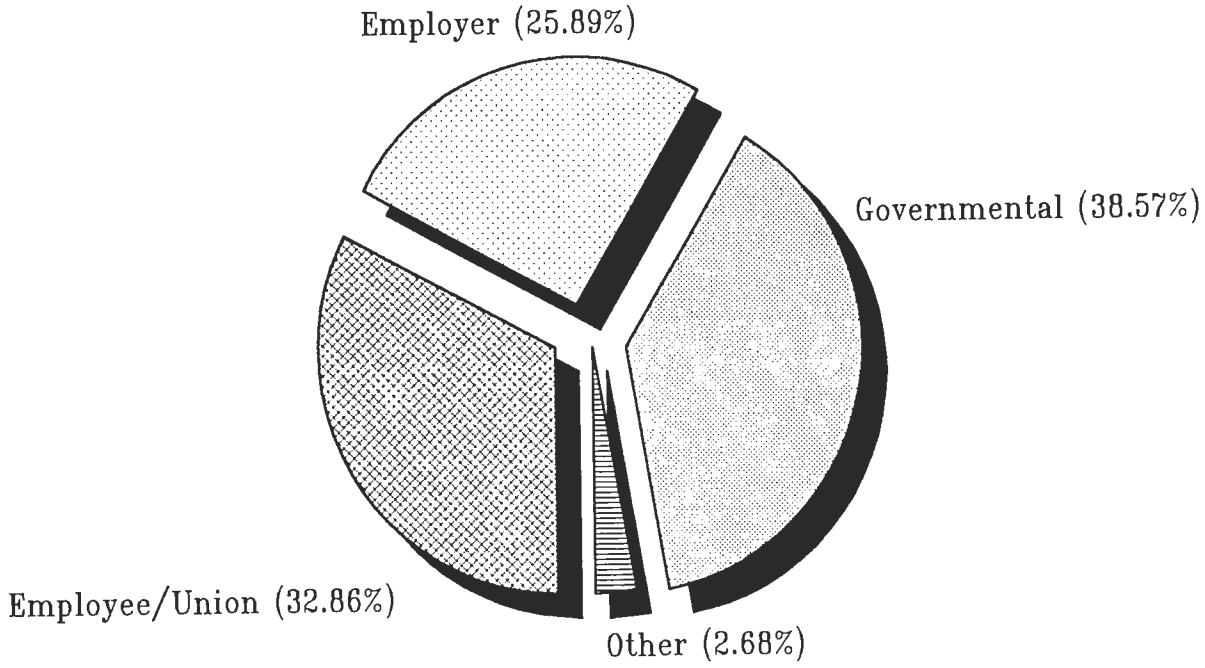



Figure 3 – FY 1986 HETA Requests by Requestor.

Table 2. HETA Requests for FY 1985 and FY 1986, by Requestor

| REQUESTOR | FY'85 Number | FY'85 % | FY'86 Number | FY'86 % |
|---|---|---|---|---|
| Employer | 119 | 20.4 | 145 | 25.9 |
| Employee/Union | 202 | 34.7 | 184 | 32.9 |
| Federal Agency | 115 | 19.8 | 104 | 18.6 |
| Occupational Safety and Health Administration | 4 | 0.7 | 3 | 0.5 |
| Mine Safety and Health Administration | 1 | 0.2 | 1 | 0.2 |
| Centers for Disease Control | 10 | 1.7 | 5 | 0.9 |
| State/Local Health Dept. | 72 | 2.4 | 48 | 8.6 |
| Other State/Local Govt | 42 | 0.2 | 55 | 9.8 |
| Other | 17 | 2.9 | 15 | 2.7 |
| Total | 582 | 100.0 | 560 | 100.0 |

**Cancer**

- epidemiologic studies of cancer clusters at a radio frequency (RF) heat-sealing operation (breast cancer), at a Department of Defense supply center (all cancers), among members of a plasterers union (lung cancer), and at a hydraulic cylinder manufacturer (leukemia)
- excessive exposures to suspected or confirmed carcinogens: polyaromatic hydrocarbons in a coke oven; methylene chloride at a manufacturer of printed circuitry; methylene chloride at a plant making janitorial supplies; dichlorobenzidine at a chemical company; formaldehyde in a school; methylene chloride at a plant manufacturing stationery products; asbestos in an office environment; asbestos in a rolling mill; perchloroethane at a dry cleaning establishment; and polynuclear aromatic hydrocarbons in roofing operations.
- excess brain tumors reported among the children of workers who manufacture television picture tubes at an Ohio plant
- exposure to PCBs in some oils used in the mining industry

**Musculoskeletal Injuries**

- eye irritation and musculoskeletal discomfort associated with prolonged use of microscopes in a laboratory
- chronic trauma disorders among seamstresses at a plant where uniforms are made (health hazard unidentified)
- excess carpal tunnel syndrome among fish processors at a cannery
- musculoskeletal discomfort among VDT users due to work-space design
- increased risk of chronic knee injury among carpet and floor layers

**Cardiovascular Disease**

- increased frequency of chest pain associated with increased use of VDTs
- excessive exposures to carbon monoxide at three facilities where fork-lift trucks are used indoors
- excess cardiovascular disease among rubber workers at an Alabama plant; work-related cause still under investigation
- heat stress in strip mining operations

**Neurotoxic Disorders**

- evaluation of neurologic effects among workers exposed to low levels of elemental mercury
- comparison of neurobehavioral performance in workers exposed and unexposed to solvents
- workers exposed to carbon disulfide

**Hearing Loss**

- excessive noise exposures at a plant manufacturing sports equipment
- hearing loss among firefighters at a major airport
- evaluation of noise hazard for New York City firefighters

**Dermatologic Conditions**

- high rates of hand and arm eczema and xerosis related to exposure to cutting oils in the machine area of a manufacturing plant

**Indoor Air Quality**

- more than 100 requests for evaluations related to indoor air quality in office environments, most due to inadequate fresh air from the ventilation system

**Hazardous Waste/Emergency Spills**

- review of two plans from Superfund Implementation Group for cleanup of hazardous waste sites
- response to 17 requests from EPA/ATSDR for assistance, including 4 industrial hygiene/medical studies, PCB exposures at a railyard in Pennsylvania, a transformer fire at a Naval Air rework facility in Virginia, a uranium hexafluoride release in Oklahoma, three PCB destruction facilities in Kansas, TCDD exposures in New York, cadmium exposures at a battery plant in New York, and sulfur exposures from a train fire in Ohio.

# B. Evaluation

Evaluation is the core of the Institute's scientific research. Hypotheses formed after identification are tested through epidemiology, toxicology, and kinesiology. Evaluation may include such diverse activities as on-site inspections, sampling for toxic substances, improvement of sampling techniques, analyzing samples, developing and improving analytical methods, statistical analysis of data, and laboratory studies to determine toxic effects in experimental animals. As cause-and-effect relationships are identified, intervention strategies can be implemented to prevent health and safety problems. The majority of the Institute's evaluation work involves the leading work-related diseases and injuries.

## 1. Occupational Lung Diseases

Occupational exposures have long been recognized as the cause of several lung disorders. The lung serves as both a target organ and a portal of entry for toxic substances and is subject to exposure from many industrial dusts, fumes, and fibers. Many lung diseases, including cancers, have a relatively long latency period —up to 15 years for silicosis and 30 or more years for diseases related to asbestos exposure—and thus, recognition of the occupational component is often difficult. Because new, potentially toxic agents are now being introduced into the workplace with increasing rapidity, pre-market testing of these agents and active surveillance for the diseases they produce are of increasing importance.

**Cotton Dust Inhalation and Byssinosis**
NIOSH participates actively in the government, industry, and union task force for byssinosis prevention and has made significant progress in developing an animal model to help clarify our understanding of the byssinosis syndrome. Results of NIOSH studies specifically implicate gram-negative endotoxin as a risk factor and demonstrate the value of pre-treating (washing) cotton to reduce its toxicity.

**Coal Workers' Autopsy Study**
In FY 1986, NIOSH conducted histopathological reviews of 3,400 autopsy reports received for 1971–1980 from 27 states by the National Coal Workers' Autopsy Study. After grading and classification according to standards developed by NIOSH and the College of American Pathologists, the results showed a high prevalence of silicosis in a miner population that was relatively disease free during life. Thus, previous studies of silicosis in coal workers may have underestimated the incidence of this disease.

**Pneumoconiosis Among Surface Coal Miners**
Early studies of pneumoconiosis focused on underground coal miners because of their exposures in confined workspaces. Recently, a need for periodic medical examination of surface coal miners was recognized. In 1984–1986, approximately 1,000 surface anthracite miners were examined, and their chest radiographs were classified. The results show a significant increase in pneumoconiosis among miners who perform drilling operations at these mines. All surface mines in West Virginia and Pennsylvania have been located and asked to identify their drillers. NIOSH is now considering these results for inclusion in a criteria document and for recommendations of periodic medical examinations for surface coal miners.

**Silicosis**
When respirable dusts are first deposited in the lung, they are solubilized and transported on the pulmonary alveolar surface. To help measure the genotoxic hazards of such dusts, NIOSH has developed a new method of preparing silica dusts for mutagenicity assay. It involves a prophylactic coating for dust particles that more nearly models the early events of solubilization and transport in the lung. This method is now being evaluated to determine whether it is more accurate for measuring the genotoxic hazards of respirable aerosols.

Further studies on the early interactions of respirable dusts and lung tissues have focused on the composition of the dust surface. Current conventional tests for cytotoxicity fail to distinguish between clay and quartz and thus cannot predict the risk to workers of pneumoconiosis or fibrosis from these two substances. Results reported in FY 1986 show that the initial interaction between respirable dusts and pulmonary surfactant detoxifies silica and clay dusts but that a subsequent macrophage digestive process may restore dust toxicity in a manner that is dependant on characteristics of the dust surface.

**Diesel Exhausts**
Because preliminary animal studies have suggested an association between exposure to diesel particulates and adverse health effects, NIOSH has developed and tested a method to estimate exposure to diesel particulates in coal mines. Conventional sampling techniques for respirable dust (cyclone pre-separators and final filters) do not distinguish between diesel particulate and coal dust. However, because diesel and coal particulates differ in aerodynamic size (diesels being predominantly smaller than one micrometer in aerodynamic

diameter), NIOSH has used personal impactors that separate particulates by inertial means. Diesel particulate concentrations approach or exceed 1.0 mg/m$^3$ in some mine-face areas and haulageways. This method enables engineers to measure the contribution of diesel sources to respirable dust and to target control efforts to achieve maximum dust reductions.

**Particulate Content of Lung Tissue**
Efforts to determine the particulate content of human lungs are designed to relate the composition and content of these particles to the disease state of the lungs. Past studies, however, have suffered from a lack of data from normal lungs with which to compare the analyses of diseased lungs. Using a system consisting of an automated scanning electron microscope and X-ray imaging analysis, NIOSH this year examined the particle contents of 91 human lungs from an urban area. The subjects died from chronic degenerative diseases, and none had overt pneumoconiosis. Statistical analysis of the results grouped by age, race, sex, smoking history, and occupational environment (dusty or not) of the subjects showed no difference in the groups. These results will be compared with the analysis now being completed of particulate burdens in lungs from individuals diagnosed as having coal workers' pneumoconiosis.

**Mortality from Cancer among Cadmium Workers**
A previous retrospective mortality study of cadmium workers showed increased mortality from respiratory and prostate cancer and nonmalignant lung disease. Extending this study by doubling the workers studied and adding five years to the original time period, NIOSH found significantly greater mortality from respiratory cancer and nonmalignant gastrointestinal disease among cadmium workers than would have been expected from U.S. rates. All deaths from lung cancer were among workers employed for two or more years. A statistically significant dose-response relationship was found between cumulative exposure to cadmium and lung cancer mortality.

**Excess Lung Cancer Following Exposure to Acid Mists**
Workers exposed to acid mists in steel pickling operations showed an elevated mortality from lung cancer. The excess was highest in workers exposed to acids other than sulfuric acid. Adjustment for potential differences in smoking habits showed that the increased risks were not likely to be explained by smoking.

**Respiratory Disease in Beryllium Workers**
At least 30,000 U.S. workers are exposed to beryllium, which causes lung dysfunction. Through its grants program, NIOSH is supporting research to characterize the type and degree of this dysfunction in workers with chronic exposure to beryllium. This year exposure-response models of beryllium effects were developed and exposure-response relationships for beryllium exposure and pulmonary function were measured in different population subgroups.

## 2. Musculoskeletal Injuries

Nearly half the Nation's workers are afflicted with musculoskeletal disorders at some time during their working lives. These conditions are the leading cause of disability in the working years and rank first among health problems in frequency of occurrence. Back problems, inflamed joints, sprains and strains, and disorders of the ankle, knee, and shoulder exceed any other single health disorder in terms of lost earnings and worker compensation payments. In the next several decades, as the average age of the work force increases, the impact of musculoskeletal conditions is expected to increase.

**Cumulative Trauma Disorders of the Upper Extremities**
NIOSH has undertaken a study to assess the contribution of job task variables and personal factors to the development of cumulative trauma disorders of the upper extremities. Results to date indicate that workers in jobs with both high force requirements and high repetition rates have 30 times the likelihood of developing hand/wrist disorders as those in lowforce/low repetition jobs. Data are being analyzed on the size of the carpal canal and the incidence of carpal tunnel syndrome to see whether anatomical factors play a part. Further studies are under way to determine what levels of grip force pose a risk for workers. Finally, interview and medical evaluation techniques were developed and will be used to evaluate the effectiveness of workplace and tool modifications in preventing these disorders.

**Ergonomic Aspects of Microscope Use**
Workers using microscopes in various industrial applications have reported visual and musculoskeletal problems. In FY 1986, NIOSH completed a site study where microscopes were used to maintain aerospace guidance devices. The study included a survey of symptoms; follow-up eye examinations; and an assessment of work practices, illumination, and work-station features. Workers with high rates of visual symptoms spent relatively more hours in microscope work and also used certain solvents (e.g., acetone and isopropyl alcohol), which would account for their greater eye redness. Illumination was judged safe but variable due to individual usage. The placement of microscopes

on table tops plus the angle of eyepieces caused some users to adopt positions that stressed their neck/back muscles. NIOSH made ergonomic recommendations for remedying these problems, including improved work practices and more flexible work stations. Observations from walk-through surveys at four other sites where microscopes were used in micro-assembly tasks added support for these recommendations.

**Back Injury and Pain**

Low-back injuries sustained on the job account for 30% of workers' compensation claims and 42% of the costs – about $15 billion annually. NIOSH has developed and validated an evaluation system for more effective treatment of low-back injuries, for identification of risk factors, and for evaluating preventive programs and intervention strategies. During FY 1986, a training program, training manual, and videotape were also developed.

NIOSH reviewed the literature on the psychosocial correlates of back pain and prepared a critique of relevant psychometric instruments. The factors reported to affect the treatment of occupational back injuries include: 1) family support; 2) motivation to recover; 3) psychological overlay (e.g., depression, anxiety); and 4) worker and family expectations. These factors will be field tested and evaluated.

Health care workers are at high risk of low back injury from lifting and handling patients. A written form that NIOSH developed to help identify potential risk factors for these injuries will be used in a research project to measure the effect of hospital equipment and furnishings on musculoskeletal injuries related to lifting.

**Injuries Resulting from Pushing and Pulling Tasks**

Manual tasks involving the pushing and pulling of materials can produce both musculoskeletal (sprains, strains) and traumatic (slips, falls) injuries. In FY 1986, NIOSH further refined a software model for predicting the horizontal and vertical foot forces (a measure of slip potential) and compressive force to the L5/S1 disc (a measure of stresses to the lower back) of such tasks. The use of microprocessors will allow on-site job evaluations of push/pull tasks and provide for redesign of task and equipment to reduce hazards.

**Neuromuscular Injuries**

NIOSH has developed unique computer software for collecting data on nerve conduction to help identify neuromuscular injuries in the workplace. Baseline data will be collected on normal individuals at U.S. Naval Hospitals in California, Maryland, and Virginia for median, ulnar, common peroneal, sural, and tibial nerves. Experimental data will then be compared with these baseline data to identify neuromuscular injuries sustained on the job and the associated risk factors. Appropriate ergonomic principles can then be applied to eliminate harmful physical stress to the worker.

**Injuries Related to Muscle Fatigue**

To determine why muscles seem more susceptible to injury when fatigued and how individual fiber types are activated in trained and untrained muscles, NIOSH is testing subjects under a variety of conditions. During FY 1986, data collection was completed for the fatigue and training components of this project. In the fatigue study, single motor units were found to discharge more slowly as fatigue occurs, and data on muscle tension showed oscillations at the terminal portion of fatigue. This oscillatory component in fatigue has not been described previously in the literature. Changes in the motor-unit discharge and in oscillations may cause internal rebounding of the muscle fiber and may lead to muscle injury.

**Musculoskeletal Stresses During Lifting**

Studies of the biomechanical capabilities of the back during lifting have concentrated on static evaluations of these exertions. Under the NIOSH grants program, additional studies have been completed that show significantly greater loadings to the back occurring under slow dynamic conditions than under static conditions. Trunk loadings change markedly as velocity is introduced into the lifting procedure, and thus static models are not good indicators of dynamic trunk load.

Asymmetric lifting (outside the body's sagittal plane) results in critical biomechanical and physiologic stresses to the body. NIOSH used a position-sensing system this year to measure biomechanical stresses to the lower back, arms, and wrist during simulated loading and unloading procedures. Heart rate was measured to indicate the physiologic cost of performing asymmetric lifting, the relative stress of symmetric and asymmetric lifting were compared with psychophysical measurements of perceived exertion and discomfort, and compressive forces on the lumbar disc were estimated through biomechanical modeling. Data are now being analyzed. Results from previous studies were published on optimal positions and angles for container handles to reduce stresses during lifting.

NIOSH has developed a set of recommendations for improving the NIOSH Work Practices Guide for Manual Lifting (WPG) and is currently revising the Guide. The modifications include 1) recommendations for asymmetrical load limits based on epidemiologic, bio-

mechanical, physiologic, and psychophysical data, 2) improved methods for analyzing jobs and revised sections on control procedures, 3) development of a 'decision tree' to evaluate the workplace and determine what kinds of intervention strategies should be used, and 4) a 'how-to-use' supplement to facilitate use of the WPG.

**Vibration Injuries**

NIOSH has developed a mobile laboratory for field measurement of vibration in equipment and personnel. This portable system was modified to incorporate some features from a Swedish system that was demonstrated to NIOSH through a cooperative agreement with the Swedish National Board of Occupational Safety and Health. This year, NIOSH analyzed data from a field vibration study at a paper company in South Carolina. Based on results of the study, NIOSH recommended that the seats of vehicles used by the company be properly adjusted to reduce vibration exposure to the drivers. An epidemiologic study of vibration exposure of commercial drivers is now under consideration.

Under the sponsorship of NIOSH grants, research has shown cumulative trauma to the hand caused by tool vibration and tool weight. These factors affect muscular contraction, tactile sensitivity, localized muscle fatigue, and the general level of comfort.

## 3. Occupational Cancers

Several environmental factors, including diet, alcohol, drugs, tobacco, occupational exposures, and pollutants, may contribute to the occurrence of cancer. The relationship between occupational exposures and the development of cancer is difficult to estimate because many cancers have extended latency periods, multiple exposures to several carcinogens may occur, differing life-style factors confound the picture, common cancers may develop from a variety of causes, and small subpopulations present statistical problems. Because cancer is currently the second leading cause of death in the United States, NIOSH is attempting to determine any links between workplace exposures and the incidence of cancer and to develop ways to control or prevent these exposures.

**Impact of Coal Dust in Gastric Cancer**

Epidemiologic studies have indicated an increased risk of gastric cancer among coal miners. Because there is a positive correlation between carcinogenesis and mutagenesis, bacterial metagenesis assays were performed to explore possible causes for this increase. In laboratory experiments, solvent extracts of coal dust showed considerable mutagenic activity in an acidic medium that contained nitrites (the acidic pH is comparable to that of the stomach, and nitrites are often used to preserve and color food). Extracts of tobacco snuff and chewing tobacco, which are frequently used by coal miners, also showed mutagenic activity in this acidic nitrite medium. The mutagenic activities of these smokeless tobaccos were enhanced by the presence of coal dust extracts. Further laboratory studies demonstrated that chlorophyllin, the sodium and copper salt of chlorophyll, inhibited the mutagenic activity of coal dust and smokeless tobacco. These results suggest that coal dust and smokeless tobaccos may be possible risk factors for gastric cancer.

**Screening for Carcinogens**

With more than 50,000 synthetic chemicals currently in use in the workplace and approximately 1,000 new chemicals being introduced each year, identification of the tumor-promoting potential of these chemicals is important for safeguarding human health. Because of the huge backlog of chemicals, NIOSH is evaluating an in-vitro test as a means of screening these substances. This test is based on evidence that tumor promoters impair cellular control mechanisms by inhibiting metabolic cooperation between cells, i.e., cell-to-cell communication. Contract testing by three independent laboratories has shown a high degree of agreement among the laboratories. Testing of 19 chemicals has now been completed, and the project is continuing.

**Drug Interactions**

Workers are exposed to a variety of chemicals in the workplace. These chemicals may interact with each other or with other substances such as prescription drugs, over-the-counter purchases, or alcohol to produce adverse health effects. NIOSH has studied the effects in laboratory rats of the widely used solvent 1,2-dichloroethane (EDC), with or without concomitant doses of disulfiram (antabuse, a drug used in alcohol abatement programs). In 1977, 5.1 million tons of EDC were produced in the United States, and NIOSH estimates that 18,000 workers may be exposed. Results of these laboratory studies show that blood levels of EDC were increased 5-fold after disulfiram treatment, and other studies suggest that the metabolism of EDC is altered in the presence of disulfiram. Animals treated with EDC and disulfiram developed a high incidence of intrahepatic bile duct cholangiomas (not observed after either chemical alone), testicular interstitial cell tumors in male rats, and mammary adenocarcinomas in female rats.

**Exposure to Polychlorinated Biphenyls**
Polychlorinated biphenyls (PCBs) have been shown to cause liver tumors in laboratory animals. Updating a previous retrospective cohort mortality study of workers exposed to PCBs, NIOSH observed the cohort for an additional seven years and found a statistically significant excess of deaths from cancer of the liver and biliary passages. This excess occurred mainly among women employed in one plant. The small number of deaths, however, makes any association with exposure to PCBs difficult to access.

**Dry Cleaners Using Perchloroethylene**
Because mice exposed to perchloroethylene (PCE) develop an excess of liver cancer, NIOSH conducted a retrospective cohort mortality study of workers in the drycleaning industry who use PCE. The majority of the 1,690 workers in this study, who were from four labor unions, also had potential exposure to petroleum solvents. Mortality from all cancers combined was greater than expected, but no deaths due to liver cancer were observed. Only cancer of the urinary tract resulted in a statistically significant excess of deaths. In a subcohort, identified from union records as exposed only to PCE, fewer deaths than expected from cancer of the urinary tract were seen.

**Garment Workers Exposed to Formaldehyde**
In order to assess the possible human carcinogenicity of formaldehyde, NIOSH conducted a retrospective cohort mortality study of workers exposed for at least three months to formaldehyde in three garment facilities which produced permanent press garments. A total of 11,300 workers contributing 188,025 person-years were included in the study. Vital status was successfully ascertained through 1982 for over 96% of the cohort. The average TWA formaldehyde exposure at the three plants monitored in 1981 and 1984 by NIOSH was 0.15 ppm, but past exposures may have been substantially higher. In general, mortality from nonmalignant causes was less than expected, except for bronchitis (SMR = 190). A statistically significant excess in mortality from cancers of the buccal cavity (SMR = 343) and connective tissue (SMR = 364) was observed. Statistically nonsignificant excesses in mortality were observed for cancers of the trachea, bronchus and lung (SMR = 114), pharynx (SMR = 112), bladder (SMR = 145), leukemia and aleukemia (SMR = 113), and other lymphopoietic neoplasms (SMR = 170). Mortality from cancers of the trachea, bronchus and lung was inversely related to duration of exposure and latency. In contrast, mortality from cancers of the buccal cavity, leukemias, and other lymphopoietic neoplasms increased with duration of formaldehyde exposure and/or latency. These neoplasms also were found to be highest among workers first exposed during a time period of high potential formaldehyde exposures in this industry (1955–1962). However, it should be recognized that these findings are based on relatively small numbers and that confounding factors may still exist. The results from this investigation, although far from conclusive, do provide evidence of a possible relationship between formaldehyde exposure and the development of upper respiratory cancers, leukemias and other lymphopoietic neoplasms in humans.

**Mortality Among Workers Exposed to Cutting Fluids and Abrasives**
A study of workers exposed to cutting fluids and abrasives in the manufacture of ball bearings showed significant excesses of stomach cancer among white men using cutting fluids. Excesses in cancer of the pancreas were also found among white men with grinding or machining experience. This study confirms earlier findings of excess digestive cancers among persons engaged in this work. Exposures of potential importance in metalworking facilities include cutting fluids, abrasive dusts, anti-rust oils, and oil smoke. Potential carcinogenic agents include nitrosamines, polyaromatic hydrocarbons, abrasive dusts, and chlorinated oils.

**Mortality in Electronics and Electromechanical Production**
Concern over cancer deaths at a plant that produces electronics and electromechanical components for aircraft and missiles led to a NIOSH proportionate mortality study, contracted with the United Auto Workers. Production activities include machining and grinding, armature construction, and various assembly operations. Potential exposures involve halogenated solvents, cutting fluids, solder fluxes, and several distinct polymer systems, e.g., epoxy-, cyanoacrylate-, and acrylonitrile-based resins. Results showed 1) excess proportions of deaths due to cancer of the pancreas in both men and women, 2) an association between colon cancer in women and exposures to epoxy-like materials, 3) ovarian cancer possibly related to electromechanical assembly operations, and 4) pancreatic cancer in men following exposures to epoxy-like materials.

**Exposure to Uranyl Fluoride**
NIOSH conducted a mortality study among workers exposed to uranyl fluoride at a facility using a gaseous diffusion process to enrich uranium. Although the number of deaths due to cancer of the stomach and cancer of the lymphatic and hematopoietic system were greater than expected, the excesses were not statistically significant. When two subcohorts of workers with relatively greater potential for exposure to uran-

ium compounds were identified, analysis of the mortality data yielded results similar to those of the total cohort.

**Carcinogenic Properties of Nitrous Oxide**
A study of nitrous oxide, the most commonly used inhaled anesthetic in the United States, was supported by the NIOSH grants program. Results of this and other studies indicate that nitrous oxide administered to mice at the maximum tolerated dose for 18 months has no carcinogenic potential and no significant non-hemopoietic chronic toxicity.

**Benzene Toxicity in Bone Marrow**
Research supported by the NIOSH grants program has demonstrated that bone marrow stromal cells are more sensitive targets of benzene or its metabolites than are hemopoietic precursors. This toxicity to stromal cells causes altered hemopoiesis or blood cell formation. The results point to a mechanism of toxicity that involves an imbalance in the secretion of regulatory factors by stromal cells and reemphasizes the need to protect workers from exposure to benzene.

**Asphalt Fumes**
An estimated 116,000 workers are exposed to asphalt fumes, which have been shown to cause cancer. NIOSH is studying these fumes to determine the carcinogenicity and co-carcinogenicity of various components. The fumes have been generated under controlled conditions at 316° and separated by high pressure liquid chromatography into five fractions: aliphatics (65%), phenols (11%), phenylethones/dihydrofurones (10%), thiophenes (8%), aliphatic ketones (4%), and other (2%). These fractions will now be tested separately and in combination by painting them on the skins of test animals. After active components are identified, industrial hygiene indicators can be developed to control the risks to workers in the construction and manufacturing industries.

## 4. Severe Occupational Traumatic Injuries

Amputations, fractures, eye loss, lacerations, and death are the most severe results of occupational injuries. These tragic outcomes exact an enormous toll on the human and economic resources of the Nation. The National Safety Council has estimated that 2.1 million workers in 1981 sustained disabling injuries and that 70,000 of these workers were permanently impaired. The cost of workplace injuries in that same year approached $32.5 billion. NIOSH has several programs designed to identify the causes of these severe injuries and to develop ways of preventing them.

**Injuries Involving Programmable Robots**
The increasing use of programmable robots in industry has resulted in exposure to the hazards of moving parts on these robots. In FY 1986, NIOSH completed a literature review of human reaction time to emergency situations and analyzed reports from the Motor Vehicle Manufacturers Association for robot speed as a factor contributing to injury. Almost 50% of the injuries occurred during the performance of corrective maintenance with a robot running at full speed. A slow-speed option for such situations would reduce the energy available for producing injury and would allow greater human response time. No injuries were reported when robots were moving at reduced speed during maintenance.

Sensors are being developed that will detect humans present in the working area of robots and will then interrupt robot motion. In FY 1986, NIOSH developed a three-level safety system consisting of optical, ultrasonic, and pressure-sensitive sensors. These were interfaced with a laboratory robot to demonstrate the safeguards they provide. NIOSH also completed in-house work on guidelines for safe maintenance and servicing of robots.

**Falls from Painted Steel Structures**
Architects and designers often specify prepainted steel beams for construction to eliminate the need for costly painting after a structure has been erected. However, the paint may make the beams slippery under certain conditions and thus subject the workers to possible falls and severe injury. NIOSH is studying the slipperiness of such beams and will determine whether to recommend that preapplied protective coatings meet a specified coefficient of friction to prevent the risk of falls.

**Explosive Hazards of Grain and Feed Dusts**
In the past decade, 200 explosions in U.S. facilities that handle agricultural products have resulted in 139 deaths and 422 injuries. Through its grants program, NIOSH has measured the burning velocities of two combustible dusts—mixed grain dust and cornstarch—and of methane/air mixtures. The results will permit storage designs and housekeeping procedures that prevent these traumatic accidents.

**Feedback and Safety**
In a study supported by the NIOSH grants program, all employees in 21 work units of a paper mill in Massachusetts were involved in identifying hazardous conditions, safety targets, and performance levels for each unit. When feedback was provided regarding the safety targets, performance improved significantly.

Peer involvement, which is cost effective and non-intrusive, can alert workers to hazardous conditions in the workplace and thus reduce the rates of accident.

## 5. Cardiovascular Diseases

More deaths in the United States result from cardiovascular diseases (CVD) each year than from any other disease category. More than 960,000 deaths in 1980 were attributed to this group of diseases, which includes ischemic heart disease, hypertension, and cerebrovascular and peripheral vascular diseases. Although the contribution of occupation to the morbidity and mortality from CVD is not known and personal risk factors (cigarette smoking, diet, and obesity) can play an important role, NIOSH recognizes that any effect of the workplace that increases the incidence of these diseases should be explored.

**Carbon Disulfide**

Chronic exposures to carbon disulfide ($CS_2$) have been linked to an increased incidence of cardiovascular disease (CVD). Approximately 700,000 workers in the United States are exposed to $CS_2$. Using male Sprague-Dawley rats exposed by inhalation to $CS_2$ for up to 6 months, NIOSH is studying the mechanisms of action by which $CS_2$ might cause CVD. It has been hypothesized that $CS_2$ causes CVD by affecting thyroid function, which in turn would lead to an elevation of serum lipids as a precursor of atherosclerosis. Serum lipid profiles and serum concentrations of thyroid hormones were determined in rats after 30, 60, and 120 days of exposure. However, under the conditions of this experiment, no elevation of serum lipids was found.

**Exposure to Carbon Monoxide and Mortality from Heart Disease**

In a retrospective study to determine mortality from heart disease following exposure to carbon monoxide (CO), NIOSH examined data on mortality due to arteriosclerotic heart disease (ASHD) among 5,529 bridge and tunnel officers in New York City. Tunnel officers with 10 or more years employment had significantly higher mortality rates from ASHD than did bridge officers with similar service but whose duty subjected them to less CO exposure. Tunnel officers also experienced a significant decline in risk after cessation of employment when compared with bridge officers; most of the risk had dissipated in as little as five years. These findings combined with other studies showing a relationship of cigarette smoking to cardiovascular mortality suggest that CO may play an important role in the pathophysiology of cardiovascular mortality.

**Sudden Death at Work**

In a study of sudden deaths at work in Allegheny County, Pennsylvania, from 1979 through 1982, NIOSH found an age-adjusted death rate from natural causes among white males of 11.2/100,000. This was twice as high as the death rate for fatal injuries in the same population. Over 90% of the deaths from natural causes were due to heart attacks. Men who died on the job from sudden cardiac death were more likely to be in a blue collar occupation; the difference was statistically significant. Coroners' records were a much more comprehensive source for identifying all sudden deaths in this study than were state vital statistics and are thus a potential basis for a national surveillance network of sudden deaths at work.

**Lead Burdens and Hypertension**

To investigate a possible relationship between hypertension and exposure to lead, a NIOSH-sponsored study validated a shortened diagnostic method for use as an outpatient procedure. Persons with past exposures to lead may not have high blood lead levels if the lead has been deposited in body tissues. This method involves administering a substance called a chelating agent that bonds with lead deposited in the tissues and brings it into the blood where it can be measured. The blood lead level can then be correlated with the degree of hypertension. This epidemiologic tool can be used to evaluate the chronic effects of cumulative lead exposure in case-control studies.

## 6. Disorders of Reproduction

Spontaneous abortions, birth defects, sterility, and male impotence are some of the adverse effects on the reproductive system that can result from occupational exposures to toxic substances. NIOSH is seeking through its research programs to identify teratogens, mutagens, and other reproductive hazards present in the workplace and to develop means of controlling or preventing exposures to them.

**Screening for Reproductive Toxicity**

Full-scale testing of chemicals for reproductive toxicity is expensive and time consuming, and adequate testing of all the many chemicals currently in use in the workplace is clearly impossible. Thus, a quick and accurate screening procedure is needed to help set priorities for testing. NIOSH is using an in-vivo toxicity assay developed by Chernoff and Kavlock (J Toxicol Environ Health 1982;10:541) to conduct such screening. CD-1 mice are given the test chemical by oral gavage during gestation and allowed to deliver their litters. The numbers of live/dead fetuses at birth

and their birth weight, growth, and survival to 3 days are recorded as indices of reproductive toxicity. Twelve chemicals were tested in this way in FY 1986. At a workshop in Cincinnati, investigators from government, industry, and commercial testing laboratories discussed this test system and agreed that it is a useful and accurate method for detecting reproductive toxicity. In a related study, NIOSH is evaluating the potential of *Drosophila melanogaster* (fruit fly) as a screening bioassay for teratogens. Currently, 47 chemicals are being evaluated, with up to five screening tests per chemical.

**Metabolic Modifications of Glycol Ethers**

Digestion of industrial chemicals results in a wide variety of metabolites with differing toxic properties. NIOSH studied the metabolic pathway of diethylene glycol dimethyl ether, a chemical recently shown to affect both male and female reproductive capabilities in the rat. The study identified a minor metabolite, methoxyacetic acid, constituting only 4%-6% of the administered dose, as responsible for the toxicity. Thus, the toxicity of the parent compound resulted from a central ether cleavage. Since potential exposure to the glycol ethers as a group is large (NIOSH estimates as many as 200,000 workers exposed), this finding suggests that similar toxicity could result from the metabolism of certain other polyglycol ether solvents.

**Semen Analysis Following Ethylene Dibromide Exposure**

Ethylene dibromide (EDB), a highly reactive alkylating agent with mutagenic and carcinogenic properties, is widely used in pesticides and in the production of leaded gasoline. Animal studies suggest that EDB may affect spermatogenesis and fertility in males. NIOSH analyzed the semen from men exposed to EDB in six fumigation plants and corrected for age, smoking habits, abstinence, consumption of caffeine and alcohol, and other potentially confounding factors. Statistically significant decreases were found in sperm count per ejaculate and in the percentage of viable and motile sperm. In addition, increases were found in the proportion of morphological sperm abnormalities, such as tapered heads, absent head, and abnormal tails. These data strongly suggest that EDB may increase the risk for workers of reproductive impairment at EDB levels near the NIOSH recommended exposure limit and far below the current OSHA standard of 20 ppm as an 8–hour TWA.

**Semen Quality in Workers Exposed to 2-Ethoxyethanol**

In a NIOSH study of male workers at a precision metal parts company, workers exposed to 2-ethoxyethanol (2EE) showed a significantly lower average sperm count per ejaculate than did unexposed workers at the same plant. However, the average sperm concentration of the unexposed group was also somewhat lower—but not significantly—than that for other occupational populations studied by NIOSH. While these results suggest a possible effect of 2EE on sperm count, further study will be necessary to determine whether other factors may be affecting the semen quality of both groups.

**Chromosomal Changes in Workers Exposed to Ethylene Oxide**

Reports of carcinogenicity and adverse reproductive effects in animals exposed to ethylene oxide (EtO) prompted a NIOSH study of workers with occupational exposures to EtO at a petrochemical plant. Using the incidence of sister chromatid exchanges (SCE) and chromosomal aberrations (CA) in circulating lymphocytes as a measure of genotoxicity, the study found marginally significant increases in group mean SCE frequency per chromosome per cell among nonsmokers in the production unit and significant elevations of group mean SCE frequency and group mean transformed CA among laboratory workers. However, because of the complex nature of the working environment, changes in the laboratory workers cannot be attributed solely to EtO. Additional study will be needed to determine the contribution of EtO to these effects.

**Functional Deficiencies in Offspring**

Functional or structural changes in the heart and other internal organs of the offspring of exposed workers may be missed in conventional teratology testing. NIOSH is using animal models to develop new methods of assessing such chemically induced teratogenesis. This study has demonstrated that the hearts of 3-day-old rats, exposed in utero to ethylene glycol monomethyl ether (EGME), have significantly reduced activity of the enzyme ornithine decarboxylase. This deficit would not have been found during traditional morphologic evaluation. Approximately 103,000 American workers are estimated to be exposed to EGME in the workplace.

**Female Reproductive Function Following Exposure to Pesticides**

Under a NIOSH-sponsored grant, females exposed to the chlorinated insecticide, Kepone, showed a reduced ovulatory response when stimulated by gonadotropic hormones. The effect appears to be reversible, but further study will be necessary to determine whether residual effects are present and whether the effect is still reversible after prolonged exposure.

## 7. Neurotoxic Disorders

Several hundred chemicals, representing every major chemical class, have been identified as toxic to the nervous system, which plays such an important role in body function. Many chemicals are neurotoxic at or below levels that cause other health effects. Neurotoxicants may cause such effects as motor changes (gait disorders, tremors, and incoordination), sensory changes (impaired vision, hearing, and touch), and cognitive changes (loss of alertness, lapses in judgment, and personality changes). These changes may adversely affect an individual's ability to detect and react to safety hazards. The problem may be more widespread than is currently recognized because most known neurotoxicants have been identified by conspicuous, severe symptoms rather than by sophisticated tests for subtle but damaging effects.

**Mercury Neurotoxicity at Lower Burden Levels**
Reductions in finger sensitivity to vibratory stimuli were demonstrated in workers exposed to elemental mercury while manufacturing thermometers. This sensory loss in workers with urine mercury concentrations of 69–95 $\mu$g/g creatinine provides the first methodologically complete report of neurotoxicity at such low urine mercury levels. The finding complements reports of CNS deficits in memory, intelligence, and personality in workers with urine mercury levels of 50–83 $\mu$g/L (approximately 40–66 $\mu$g/g creatinine). It further supports the World Health Organization's recommended biological threshold limit for mercury of 50 $\mu$g/g creatinine. Sensitive and valid methods such as this are necessary for early detection of nervous system impairment.

**Worksite Neurobehavioral Studies**
During FY 1986, NIOSH projects in neurotoxicity worksite research from the past ten years were summarized in a single publication (Anger WK. Neurobehavioral Tests Used in NIOSH-Sponsored Worksite Studies, 1973–1983. Neurobehav Toxicol Teratol 1985;7:359–68). The document represents a significant proportion of the world's literature on worksite exposures to five chemicals – carbon disulfide, lead, methyl chloride, mercury, and Leptophos.

**Effects of Spray Paint Solvents on Behavioral Measures**
Effects of acute exposures on behavioral functions, although often reversible, may have serious consequences for safe performance of job tasks on a daily basis. Under laboratory conditions, volunteer college students were given inhalation exposures to methyl ethyl ketone and acetone, both singly and in combination, to test the effects on alertness, memory, response speed, and standing steadiness. The performance data are currently being analyzed for any significant effects. Measures of body burden (breath and blood samples), taken in the course of the study to monitor biological response, indicated additive changes from the combination exposures.

**Assessing Nerve Degeneration**
NIOSH has sponsored research under its grants program to develop new, sensitive methods for assessing the degeneration of nerve fibers as induced by neurotoxins. A major accomplishment has been the development of new instruments and procedures for measuring sensory thresholds within the large and small neurons. In animal studies, these methods have identified the distal parts of central and peripheral nerve fibers as the most vulnerable to systemic intoxication from occupational neurotoxins.

**Mechanisms of Occupational Neuropathies**
To help clarify the mechanisms of delayed neurotoxicity induced by organophosphates, NIOSH has sponsored studies in both the hen – the usual animal of choice for such studies – and the cat – perhaps a better model for extrapolation to humans. Studies to date have shown an increased phosphorylation of certain proteins of the nerves in this type of neurotoxicity. As the mechanisms of action become more clear, ways will be sought to protect the workers from these harmful effects.

**Effects of Neurotoxins on the Peripheral Nervous System**
Through grant-sponsored research, NIOSH is developing accurate, sensitive, and efficient methods for field evaluation of peripheral nerve function in workers exposed to neurotoxic agents. Devices involving temperature sensitivity and vibration energy have been used to gather baseline data on unexposed workers and to make field measurements on painters exposed to solvents. These studies will provide expanded capacity to monitor the effects of neurotoxic agents in the workplace.

**Size Distribution in Sampling for Lead Exposure**
Because blood lead levels are not always in agreement with the values predicted by usual exposure measures, NIOSH has sponsored research through its grants program to determine whether a lead Permissible Exposure Limit (PEL) based on size-differentiated sampling may be a more meaningful estimate of exposure. The data indicate that size selective sampling should be considered for incorporation into the OSHA lead standard.

## 8. Noise-Induced Hearing Loss

Hearing loss isolates its victims from their daily contacts and thus affects not only an individual's ability to do work but also the entire quality of life. Nearly 15 million Americans work in jobs that involve the production of noise and may be subject to noise-induced loss of hearing. NIOSH research has shown that hearing protectors often give less than half the noise attenuation they are reported to provide. Hearing loss is irreversible and cannot always be corrected with hearing aids. The cost of compensation for this disability in the late 1970s and early 1980s approached $1 billion.

**Impact vs. Continuous Noise**

Noise exposure may occur either as a continuous sound or as intermittent, sudden-impact sounds. NIOSH has finished equipping two laboratory systems to aid in the study of these noises. One system permits production of the two types of noise, and the other system permits measurement of the threshold for evoked auditory response. To determine the amount of hearing loss, the thresholds for evoked response after noise exposure will be compared with thresholds before exposure. Results will be used to determine whether different criteria are needed to protect workers from the risk of hearing damage from continuous and impact noise. A grant-sponsored study is also in progress to assess the effects of impulse noise.

**The Effects of Various Noise Interactions**

Since noise exposure in most industrial and military work environments rarely comes from a single source, NIOSH is supporting research through its grants program to study the interaction of various noises and vibrations and their effects on hearing. These studies involve both impulse and continuous noise and vibrations from different sources, all in various combinations. The results may lead to changes in exposure criteria that were based on single-source, continuous noise.

## 9. Dermatological Conditions

Skin diseases and disorders accounted for 40% or more of all occupational diseases reported annually from 1972 through 1982. Because of under-reporting from inadequate data systems, the true incidence may be 10–50 times greater. BLS data from 1982 show agriculture and manufacturing as the industries with the highest incidence of skin disorders. The annual cost in 1982 for lost workdays due to dermatologic conditions in all manufacturing industries was approximately $11 million. As with the lung, the skin may be both a target and a means of bodily entry that results in adverse systemic effects. Attempts to control inhalation exposure with respirators and engineering controls often overlook the contribution of dermal absorption. Dermatologic research at NIOSH is designed to identify toxic agents in commerce that are absorbed or cause dermatitis, to delineate the extent of exposure to these agents, and to identify through surveillance the occupations and industries at greatest risk of dermal exposure.

**Percutaneous Absorption**

Increasing attention has focused on occupational exposures to the skin, not only because of dermatitis, but also because percutaneous absorption may contribute substantially to the exposures workers receive from inhalation of chemicals. NIOSH studies of benzene absorption using hairless mice played an important role in supporting efforts by OSHA to lower the permissible benzene level in liquid mixtures. NIOSH has now completed additional studies with hairless mice on the dermal absorption of toluene, ethylbenzene, and aniline. Results show that dermal absorption of aniline (but not toluene or ethylbenzene) might significantly contribute to the body burden when compared with uptake by inhalation. These studies also showed an inverse relationship between the volatility of chemicals and their potential for percutaneous absorption.

**Contamination from Protective Clothing**

Workers who wear respirators and chemical protective clothing (CPC) during the clean up of toxic wastes may contaminate their skin while taking off the protective equipment. Little is known about decontaminating these protective ensembles. Some recommended decontamination agents may themselves be harmful to both the CPC and the workers. During FY 1986, NIOSH identified and compiled into a database more than 2,000 sources of information on agents and procedures for decontamination. Using these sources, NIOSH is developing a contamination-decontamination model on which to base criteria for selecting and using decontamination methods. This information is being prepared for publication next year.

This year NIOSH completed tests on three decontamination techniques for cleaning CPC: hand detergent wash, air drying, and automatic washing. The methods vary in efficiency with the toxic substance being removed and the material of the CPC. Thus, decontamination techniques must be experimentally evaluated to prove their efficiency in each case.

**Chronic Repeated Mechanical Trauma to the Skin**
Proceedings of the symposium, "The Chronic Effects of Repeated Mechanical Trauma to the Skin," sponsored by NIOSH in 1983, were published in FY 1986 (Susten AS. The Chronic Effects of Mechanical Trauma to the Skin. Am J Ind Med 1985;8:281–8). This is the first extensive effort to gather, organize, and disseminate information on the effects of repeated microtraumas to the skin. It highlights the important role that microtraumas often play in the development of commonly reported job-related skin diseases. It also identifies a potentially controllable factor for the prevention and/or reduction of job-related skin diseases.

**Bioassay for Dioxin**
Chloracne is one of the most common effects of dioxin (TCDD) exposure in humans and is thought to result from induced epithelial differentiation. Based on such dioxin-induced dermatologic alterations, research sponsored by the NIOSH grants program has developed an in-vitro assay for dioxin-like chemicals. This assay can be used to screen biological samples of various types in occupational settings that carry a high risk for dioxin exposure.

## 10. Psychological Disorders

Jobs and work environments that create stress for the worker may contribute to a variety of psychological disorders, including emotional and behavioral disturbances and some mental and psychosomatic illnesses. Estimates of annual medical, employment, and productivity costs for stress-related psychological disorders run into tens of billions of dollars. Data from workers' compensation records rank claims for occupational stress-related psychological disorders among the most common and costly claims for all occupational injury or disease. Evolving patterns in the nature of work suggest no lessening of this problem. The potential for exposure to occupational stress is nearly unlimited because job stress can exist in all work situations and is not limited to specific occupational settings as are chemical or physical hazards.

**Extended Work Hours**
To test the impact that extended work hours (12-hour shifts) have on physical and psychological fatigue, NIOSH has developed an automated, self-administered test battery. This is designed to assess health and performance decrements associated with fatigue by testing perceptual-motor skills, sensory discrimination, and reasoning abilities. It was validated this year in the laboratory in a simulation of 12-hour work days and showed decrements in verbal reasoning, mental arithmetic, reaction time, hand steadiness, and subjective ratings of alertness. It was then used at the worksite with a sample of nuclear power plant operators who converted from an 8- to a 12-hour rotating shift. Even after 7 months' adaptation to the new schedule, the workers showed declines in several measurements. The test battery will now be used to identify occupations at risk for accidents or judgment errors under extended work schedules.

**Measuring Job Stress**
In FY 1986, NIOSH conducted a 3-day workshop, which brought together 15 recognized experts in the field of job stress to discuss the most effective means for evaluating stress and strain. From these deliberations, two promising methods for assessing stress were selected for evaluation and validation. These are 1) psychometric evaluation using a generic tool developed by NIOSH for assessing job stress and strain, and 2) an evaluation of the immunosuppressive effects of stressful conditions in jobs and individual job tasks. The workshop also yielded a proceedings document that provides a state-of-the-art analysis of methodological issues in occupational stress research. This document will be published to provide direction for improved strategies in stress research.

**Stress and Accidents**
Through a search of the literature, NIOSH found very few studies on the relationship of stress factors to unsafe behaviors and work accidents. A contractor was then directed to identify databases that contain information on both stress and accidents. Of the 47 databases identified, two seemed to have the greatest potential for scientific analysis and provided detailed bibliographies of the stress and accident literature. A review of project protocol the Fatal Accident Circumstances Epidemiology (FACE) study indicated that limited data on stress factors can be obtained from the victim's spouse, supervisor, and coworkers. Using all this information, NIOSH developed a conceptual model linking stress to accidents. The model suggests that stress can impact unsafe behaviors through impaired worker capacities such as poor judgment and slowed reaction time.

## 11. General Evaluation

This section covers evaluation activities that apply to more than one of the leading work-related diseases and injuries or to other conditions not on that list.

**Risk Assessment**

The Institute carries out risk assessment activities at several levels through a cooperative agreement with the Massachusetts Institute of Technology and in the Subcommittee on Environmental Health Risk Assessment of the Committee to Coordinate Environmental Health-Related Programs (CCEHRP). Three reports were generated by NIOSH risk-assessment activities in FY 1986: 1) Quantitative Risk Assessment of Lung Cancer in U.S. Uranium Miners. 2) Potential Indirect Mechanisms of Carcinogenesis: A Preliminary Taxonomy, and 3) A Pharmacokinetic-Mechanism-Based Analysis of Carcinogenic Risk of Perchloroethylene.

**Laboratory Quality Assurance**

The Proficiency Analytical Testing (PAT) program was begun by NIOSH in 1972 to improve the quality of industrial hygiene analyses throughout the country. The program continued to grow in FY 1986 with quality audit samples being provided quarterly to 760 laboratories. Improvements were made in three categories of audit samples: silica—a new silica matrix (talc) was introduced; asbestos—amosite was introduced and a dust generation system was tested; solvents—the new solvent, cellusolve acetate, was introduced. Performance of the phase contrast microscope for counting asbestos fibers was documented, and a significant improvement was made in the interlaboratory agreement for this procedure. Also during FY 1986, PAT changed from a completely NIOSH-supported program to a cooperative effort between NIOSH and the American Industrial Hygiene Association. While NIOSH now pays only for PAT samples sent to government laboratories, it continues to analyze data from all laboratories and to give technical consultation.

**Analytical Chemistry Support for Research and Field Activities**

To support its research and field studies, NIOSH maintains analytic chemical capabilities through its own laboratories and through two contract laboratories. In FY 1986, 6,000 samples were analyzed in support of health hazard evaluations (HHE), and short-term analytic methods were developed in response to some of these requests (oxydianiline, benzophenone tetracarboxylic acid dianhydride, tallowamine, aspartame, and diethylthiophosphate in urine). Assistance for the National Occupational Health Survey of Mining involved analysis of 1,125 samples for asbestos, silica, and metals as well as chemical characterization of other samples from individual mines. Field Investigation and Research programs submitted 11,947 samples for analysis. An inhalation study designed to assess the health effects of common solvents produced 600 samples for analysis, and another 100 samples came from a study conducted with the National Toxicology Program on a carcinogen promoter. A total of 433 membrane filter samples were screened by Magiscan for airborne asbestos and 733 were analyzed by phase contrast microscopy. Correlation of the two methods is now being evaluated.

**Development of Analytical Methods**

The evaluation of toxic exposures depends on the ability to detect and measure toxic contaminants in the workplace. NIOSH is always alert to the need to develop and modify methods to permit such evaluation. The *NIOSH Manual of Analytical Methods* contains a method (# 7400) for sampling and analyzing asbestos fibers. This year NIOSH conducted experimental work on another counting method for asbestos using the transmission electron microscope. This method involves a procedure for clearing the filter and the development of software for automated counting. It will be tested for accuracy and efficiency in comparison with the older method. In addition, electrostatic effects on the accuracy of asbestos sampling have been investigated and the results published. All filter-cassette manufacturers and distributors in the United States now provide conductive cowls and cassettes consistent with NIOSH recommendations for improving the accuracy of asbestos measurements.

A prototype direct-reading monitor has been developed for measuring ammonia. It was tested in the laboratory this year for precision, general accuracy, and the effects of potential interferences. Once fully developed, it will provide immediate feedback to both workers and employers on the extent of exposure.

An analytical method was developed for industrywide studies to assess exposure to 4,4'-methylene dianiline (MDA), a catalyst used in epoxy resin systems, and 4,4'-methylene bis (2-chloroaniline), a reactant used in the production of rigid urethane foams. Both materials are suspected human carcinogens, and MDA has been a subject of rulemaking in both EPA and OSHA. The new procedure allows air monitoring for both compounds at levels as low as 10 parts per trillion.

Another method was developed to measure 1,3-butadiene, a major product of the petrochemical industry that has been classified as a potential carcinogen, teratogen, and reproductive hazard. The NIOSH method, which determines sub-part-per-million traces of 1,3-butadiene in air by collection on charcoal and analysis with high-resolution gas chromatography, has been successfully field tested. Using results from this method, NIOSH is responding to an OSHA request

for comments on the effects and control of 1,3-butadiene exposure.

Based on successful sampling and analysis methods developed previously that use reagent-coated sorbents for formaldehyde and acrolein, NIOSH has expanded this technique to other aldehydes: furfural, glutaraldehyde, and—this year—to valeraldehyde. This year NIOSH used Fourier Transform Infrared Spectroscopy to study the reactions that take place in this method and discovered a new intermediate step that explains variations in the reactivity of some of these compounds. Written procedures for sampling and analysis of furfural, glutaraldehyde, and valeraldehyde were submitted for the next update of the *NIOSH Manual of Analytical Methods*.

The collection of breath samples provides another monitoring dimension to industrial hygiene by reducing the need for invasive (blood-sampling) procedures. NIOSH this year improved the design of a prototype device for collecting organic solvents present in expired breath and compared it with the standard bag-sampling technique for workers exposed to m-xylene. The precision and accuracy of the methods were comparable. The new device permits large numbers of workers to be biomonitored routinely for uptake of toxic chemicals without resorting to invasive procedures. Through breath sampling, several pathologic disorders related to occupational exposures can be diagnosed via analysis of endogenous compounds.

Performance tests were completed this year on an improved method NIOSH has developed for sampling and analyzing silica and respirable quartz. Results showed that no changes in the method were needed. Evaluation of the new X-ray diffractometer used in these analyses was completed, and a technical report describing its use was prepared. These studies contribute information needed for the sampling and analysis of silica in the workplace.

Additional methods were developed and/or validated this year for determining MBOCA in urine as a measure of dermal absorption; blood levels of methylethyl ketone, acetone, and ethanol; 2-ethoxyacetic acid (the major metabolite of 1-ethoxyethanol), levels of the insect repellent, m-N,N'-diethyltoluamide (M-DET), in urine as a measure of human dermal exposure.

In responding to an emergency in which several workers developed acute methemoglobinemia from handling a rubber adhesive that had not previously caused health problems, NIOSH determined by gas chromatographic analysis that the adhesive was contaminated with dinitrobenzene.

**Biological Monitoring**

A method using pyrene and its metabolite, 1-pyrenol, as a marker has been validated in the laboratory for biological monitoring to assess worker exposure to coal tar pitch. The detection limit for 1-pyrenol was 0.1 $\mu$g/L in urine. Urine specimens contained trace amounts of 1-pyrenol with ranges of 0.34–2.0 $\mu$g/L for smokers (n = 5) and 0.29–0.69 $\mu$g/L for nonsmokers (n = 5).

Methods of biological monitoring for several other compounds were also developed, including MEK, acetone, and ethanol in blood, and M-DET, MBOCA, and 2-ethoxy acetone in urine. The latter method was used to assess exposure of shipyard painters to 2-ethoxy ethanol.

**Removing Contaminating Liquids**

Liquid spills are a common occurrence in the chemical industry. Through its grants program, NIOSH has sponsored studies to characterize the contaminant film and the jet used to flush off the film. Mathematical models have been developed to predict the efficiency of the cleaning process. Such factors were considered as the role of surface roughness in affecting cleaning, the contamination from droplets formed when the jet splashes on the surface, and the mechanism of droplet formation.

## C. Control

To prevent occupational diseases and injuries, ways must be found to prevent or control exposures to workplace hazards. Through studies in engineering, ergonomics, and industrial hygiene and safety, NIOSH seeks to discover, assess, and improve measures that reduce such exposures. As the result of these studies, NIOSH recommends control technology, personal protective devices, altered work practices, hazard detection devices, and environmental and medical monitoring as a means of reducing or eliminating occupational hazards.

### Air Curtain Technology for Control of Airborne Contaminants

NIOSH is developing an air curtain to protect workers from hazardous emissions produced by a variety of industrial processes. This technology consists of a jet of air that extends along the side of the work area and acts as a curtain or wall between workers and the process. Workers may extend their hands through the air curtain to manipulate machinery and materials or may even walk through if necessary. This control technique has been applied to drop mills commonly used in rubber and plastic manufacturing industries, resulting in a 50%–70% reduction in emissions and is being applied to reduce formaldehyde emissions from wood panel gluing operations.

### Dust Control

Ventilated work stations often do not provide adequate dust control during the handling of chemical powders. To improve the efficacy of dust control, it is important to identify what tasks are causing the exposures. Workers at a plastics manufacturing plant were therefore monitored with real-time instruments tied to computers to determine sources of dust exposure during the transfer and weighing of chemical powders. A video taping system was used for task analysis. These techniques clearly identified that exposures were much higher when workers were scooping from the bottom half of fiber drums. An improved work station design, including the use of half-height drums and improved ergonomics, has been recommended to the plant. The use of real-time monitoring connected to computers and combined with videotaping is an extremely powerful new tool for identifying and controlling workplace exposures.

NIOSH is studying parameters that affect the rates of dust generation during the handling of powders. This work is being supported in part by the Environmental Protection Agency's (EPA) Office of Toxic Substances. EPA reviews premanufacturing notices to estimate potential exposures to toxic substances and hopes to use NIOSH research to more accurately predict and prevent toxic exposures to new chemicals. Preliminary tests indicate that dust generation is proportional to the distance the powder falls during handling, the mechanism by which it is dropped, and the relative humidity in the room. NIOSH has also studied two types of tests for predicting the relative dustiness of powdered materials. To monitor worker exposure and the degree of dust, NIOSH conducted a field survey this year at a plant that produces powdered acrylic resins with varying particle size and degrees of dustiness. The results will show what treatments reduce dust emissions and allow their incorporation at an early stage of the process to prevent excessive dust exposures.

The electrical charge and mass distribution of airborne dusts affect the way these dusts agglomerate and thus the methods necessary to control them. NIOSH is completing study of a modified cascade impactor to measure these properties of dusts and also the use of charged water foggers to reduce dust levels with charged water mists. Early results show a twofold increase in the efficiency of dust removal using the charged fogger. Additional research is needed to explain the parameters associated with this process.

### Asbestos

The use of asbestos in brake linings presents a potential danger to mechanics who must service these brakes. NIOSH has identified four control technologies for limiting exposure to asbestos: 1) total enclosure with vacuum-equipped ventilation; 2) cleaning the brake assembly by vacuum; 3) washing with a brush and recirculating cleaning solution; and 4) washing with cleaning solvents from aerosol cans. These measures vary widely in cost, and NIOSH is currently measuring their effectiveness through monitoring with phase-contrast and transmission electron microscopy and real-time analysis of exposures. Results are expected to contribute to the final form of the draft guidelines that OSHA recently published for asbestos control, and to several EPA guidance documents on asbestos.

Glovebags are frequently the only devices used to protect workers who remove asbestos from buildings. These bag-like devices cover the worker and have arm and hand projections through which the worker can manipulate the tools and materials. Results of NIOSH studies to date indicate that worker exposures during use of glovebags were often above the current OSHA standard of 200,000 fibers/$m^3$, over 5 $\mu$m in length, 8-hour TWA. This indicates a need for res-

piratory protection and containment barriers to improve the effectiveness of glovebags.

NIOSH measurements of post-abatement asbestos levels in air show 2–3 times the concentrations of pre-abatement measurements in the same location. This indicates that asbestos removal increased the residual levels of asbestos in the buildings tested.

This year, NIOSH completed and sent to EPA for publication "A Guide to Respiratory Protection for the Asbestos Abatement Industry," which incorporates NIOSH policy on respirator selection and use. A subsequent revision included updated information on available respirators and the new, revised OSHA asbestos standards.

**Control Technology for Emerging, Growing, or Changing Industries**

The inclusion of effective control techniques early in the design stage will help prevent toxic exposures in emerging, growing, or changing industries. A new method of paint removal using inert polymer beads for blasting was compared with conventional sand blasting and solvent stripping. Bead blasting was quicker and less hazardous than solvent stripping (no solvent-laden waste water and no exposures to methylene chloride); it was slightly slower than sand blasting and produced high levels of paint dust that often contain toxic heavy metals. Thus, a ventilated booth with supplied-air protection equipment should be used during abrasive blasting with beads.

NIOSH has completed reports on the first studies of viable emissions from processes of fermentation technology, which may result in occupational lung diseases or dermatitis. Biotechnology is expected to be a major growth industry of the next decade, and these studies, which identify the effectiveness and some limitations of this technology, are a first step toward incorporating the controls necessary for worker protection.

A new foundry process called evaporative metal casting is expected to enjoy rapid growth because of its reported cost savings. In this process, a styrofoam facsimile of the part to be cast is coated with ceramic, packed in loose sand, and evaporated on contact with the metal. NIOSH evaluated emissions from this process and compared them with conventional processes of metal casting. Major gaseous contaminants were identified as styrene, benzene, toluene, and ethyl benzene, which have been associated with lung diseases and cancer. Analysis showed higher concentrations of carbon soot, hydrocarbons, and polynuclear aromatic hydrocarbons with the new process but lower concentrations of carbon monoxide. This research is expected to spur the development of non-polystyrene resins to assure a safer process being marketed.

Gallium arsenide (GaAs) is widely used in the growing semiconductor industry to produce wafers for computers. Exposure to this compound or to any elemental arsenic present may cause cancer or lung disease. After completing three walk-through surveys of plants, NIOSH selected the process of growing GaAs crystals for priority study. Worker exposures of 300 $\mu g/m^3$ have been reported during cleanup of equipment. The development of controls will be important to prevent these exposures.

**Ethylene Oxide in Hospitals**

NIOSH has completed the most comprehensive study to date of controls for ethylene oxide used in hospital sterilizers and has identified a series of effective engineering and work-practice measures. No single hospital used the best controls in every respect, indicating the need for documentation and wide distribution of the results. The Association for the Advancement of Medical Instrumentation used the results in its latest revision of published guidelines for ventilation of gas sterilizers and the safe use of EtO. A NIOSH video tape covering engineering modifications and work practices for controlling exposures to EtO is currently the most popular tape in the NIOSH library.

**Respirators**

Several factors affect the proper use of respirators that are worn to protect workers from potentially toxic inhalants. One factor is the fitness of the individual wearer for such a device. NIOSH has studied the conditions that affect the ability or willingness of a worker to actually wear a respirator in the manner required for maximum protection. A manuscript was prepared in FY 1986 on fitness guidelines for respirator wearers. Publication is pending, but the information has already been widely disseminated and should impact a large, cross-industry segment of the workforce. In another study, sponsored by the NIOSH grants program, the physiologic and psychophysiologic effects of respirator use are under investigation.

To monitor the efficiency of respirators, NIOSH is developing and testing various methods for sampling inside the facepiece. Laboratory testing was completed this year for a monitor that can be placed inside the face mask to detect mercury. Such a sensor can monitor worker exposure to toxic vapors inside the mask and can warn the wearer when concentrations of vapor exceed a predetermined level. This would reduce reliance on the sense of smell and also allow safe use

of respirators for substances that have no warning properties such as odor. In another study inside the face mask, NIOSH this year validated a method for continuously sampling the exhaled breath of a worker wearing a respirator. This was shown to be an accurate way of determining how much exposure the worker received, and thus how much protection the respirator provided against organic vapors.

How well a respirator fits the wearer will determine how effective the protection is. NIOSH conducted experiments this year to determine the mathematical relationship between the pressure inside the facepiece of several respirators and the volumetric rate of leakage from the facepiece. Above a given pressure, the leakage rate was a decreasing function of the pressure, and the effect would be dependent on the texture of the human face. Since the present laboratory methods cannot be used with human subjects, new methods will be developed for human use.

NIOSH is developing improved methods for evaluating respirators by testing the performance of the sorbent filters in cartridges against specific organic vapors. Breakthrough time – or the time before the vapor breaks through the filter – is determined as a function of sorbent weight. All compounds tested to date show a linear relationship between breakthrough time and sorbent weight. This research is expected to lead to new and improved methods for testing respirators and may impact on the regulations in 30 CFR Part 11. In a separate but related study, NIOSH responded to a request by the West Virginia National Guard to test the performance of respiratory protective equipment against methyl isocyanate (MIC). After testing the efficiency of organic vapor, acid gas, and methyl amine respirator cartridges against MIC, NIOSH recommended that air-purifying respirators never be used in MIC environments because of extremely short breakthrough times and inadequate olfactory warning properties. Only air-supplied, preferably self-contained breathing devices were recommended.

A study sponsored by the NIOSH grants program has demonstrated significant differences in the adsorption qualities of respirators from three major suppliers. Using an adsorption model developed by Wheeler and Dubinin, the study has shown different degrees of adsorbent activation and different amounts of carbon in the cartridges from commercial respirators containing activated carbon. This indicates the importance of testing respirators under the conditions in which they will be used.

NIOSH tests various types of respirators for certification and compliance with applicable requirements specified in 30 CFR Part 11 and 30 CFR Part 74, monitors off-the-shelf units for performance evaluations, investigates user complaints, and performs in-plant audits of manufacturing plants. In FY 1986, the testing program issued 361 certification decisions (approvals, extensions, and denials) for respirators and conducted 18 in-plant system audits.

Some current test procedures for respirators are technically obsolete because they do not measure performance during actual use, consider variations in subject size and levels of use, test at high or low temperatures, or monitor physiological or performance parameters continuously. In FY 1986, NIOSH conducted studies on new and improved test methods. When these are validated, they will be proposed for inclusion in the NIOSH Respirator Testing and Certification Program under the 30 CFR provisions.

The NIOSH Certified Equipment List was published this year in a new format designed for easier use, a new safety manual was prepared, and new safety measures were implemented in the certification laboratories.

**Hazards of Wearing Protective Equipment**

Workers who wear protective clothing and respirator ensembles are potentially at risk from the effects of the equipment itself. NIOSH has studied the physiological effects on healthy volunteers of four different protective ensembles at varying workrates. Results indicate that wearing protective clothing and respirators causes significant stress to the cardiorespiratory and thermoregulatory systems, even at low work intensities in neutral environments. Decrements of up to 95.6% in exercise-tolerance time were observed. Thus, it is important to closely monitor the individuals wearing such equipment and the conditions under which they are working.

**Protective Clothing**

The performance of specific chemical-protective-clothing (CPC) materials varies widely depending on the chemicals encountered. Thus, the resistance characteristics of specific CPC must be evaluated against specific challenge substances if appropriate CPC is to be selected intelligently. NIOSH is developing a computerized database for information on the chemical resistance of CPC materials. A decision logic for proper CPC selection is included. In FY 1986, about half the data currently available was entered into the system, and the rest should be completed early

in FY 1987. The data will then be provided to users on disks with a program that facilitates access.

The selection of CPC for specific tasks is often based on resistance data for generic materials rather than for manufacturer-specific materials. NIOSH completed a project this year demonstrating that CPC materials with the same generic name may have different resistance characteristics if produced by different manufacturers. Two generic materials – nitrile and neoprene – were exposed to three chemicals each. Then eight gloves made from nitrile by different manufacturers and five gloves made from neoprene by different manufacturers were tested for breakthrough in various product-chemical combinations. After correction for thickness variations, significant variability between manufacturers was found. Thus, CPC testing must be done with the specific chemical mixture to be encountered in the workplace and with a specific manufacturer's product. These findings have been incorporated into the NIOSH CPC Decision Logic.

Because chemical degradation data are often used to select CPC, NIOSH this year tested the validity of such degradation data (weight, volume, and thickness) against breakthrough times and steady-state permeation rates as a measure of the effectiveness of CPC. The correlations were very poor indicating that chemical degradation is not currently a viable surrogate for predicting chemical permeation.

NIOSH is also testing CPC under actual use conditions. During use, a garment undergoes flexing and other physical stresses that may affect its resistance qualities. Data from these tests will further aid in the selection of proper CPC for specific situations

The use of personal protective equipment to prevent skin contact with toxic materials may result in serious decrements in human performance. This is especially true for tasks requiring manual or hand-tool dexterity when protective gloves must be worn. An earlier NIOSH study with the Industrial Engineering Department at West Virginia University showed a 15%–37% increase in time required to perform a simple task with hand tools while wearing chemical protective gloves compared with unprotected hands. The project is now being expanded to other tasks and other types of protective clothing. In FY 1986, NIOSH added the new tasks of controlling a simulated chlorine leak by capping the valve of a 150-pound chlorine cylinder and controlling a simulated leak in an overturned gasoline tank truck by clamping the dome cover. Data collection will be completed in FY 1987.

**Worker Awareness**

NIOSH is studying ways to increase worker awareness as a means of reducing exposures to hazardous materials. A company that uses hydraulic fluids, solvents, and corrosive agents in the manufacture of auto equipment parts was selected for study. The company currently uses material safety data sheets and safe-use forms to inform its workers about chemical hazards and ways to cope with them. This year a NIOSH contractor reviewed these materials in light of NIOSH guidelines and suggested revisions to better organize the information, reduce the level of technical language, and increase reader comprehension through the use of pictures. Worker knowledge and compliance with safe work practices before and after the revisions will now be assessed using knowledge tests and behavior sampling to determine failure to carry out prescribed safe practices.

**Improving Exhaust Hoods**

To improve the efficiency of exhaust hoods used in industrial ventilation, NIOSH has sponsored research to increase the capture ability while reducing the air flow through the hood. With minimal effort it is possible to reduce the required flow rate by about 15% while increasing the hood capture efficiency to 100% under ideal conditions. This should enable designers to increase the efficiency of exhaust hoods while keeping the operating costs low.

## D. Dissemination

To be effective in combating occupational safety and health problems by reducing and preventing occupational hazards, the results of research must be applied in the workplace. NIOSH disseminates the results of its research efforts to inform the public, to recommend standards, and to share information with others who are working to improve workplace conditions. Informed individuals and organizations – both public and private – can cooperate in preventing occupational hazards and can make more progress than would be possible through Institute action alone. To disseminate information, NIOSH prepares criteria and recommended standards; issues hazard alerts and intelligence bulletins; publishes booklets, manuals, and articles in scientific journals; develops and presents educational and manpower-training programs; develops, maintains, and provides access to databases; participates in scientific meetings and conferences, consults with representatives of industry and labor on specific problems, and cooperates with others who have mutual interests.

**Educational Resources**

An adequate supply of qualified personnel and of educational and informational programs is needed as resources to carry out the purposes of the Occupational Safety and Health Act. NIOSH assesses requirements for these resources, evaluates current programs, monitors trends, and identifies gaps between manpower needs and supply. This assures effective use of funding and expertise for educational and training programs in the academic and non-Federal sectors. To this end, the Institute continued in FY 1986 to guide, administer, and monitor grants for training projects and for the Educational Resource Centers (ERCs). In the 1985–1986 school year, 1,030 students were enrolled in such grant programs full-time, 388 students took professional preparations on a part-time basis, and 1,879 students from other disciplines took one or more occupational safety and health courses as electives. In the ERC program alone, 597 students were enrolled full-time: 260 in industrial hygiene, 124 in occupational medicine, 108 in occupational health nursing, 80 in occupational safety, 17 in several allied disciplines, and 8 as occupational safety and health professionals.

**Schools of Engineering**

Project SHAPE (Safety and Health Awareness in Preventive Engineering) this year focused on incorporating instructional programs in occupational safety and health into the curricula of two major colleges of engineering: Georgia Institute of Technology and Tufts University. The Georgia Tech program was presented as the technical elective course, Occupational Safety and Health in Engineering. Formal evaluation of the program was positive, and the course is scheduled again for spring quarter 1987. The Tufts program has resulted in a report entitled, "Occupational Safety and Health Materials for Integration into Engineering Curricula." Formal evaluation of this program will be completed in FY 1987. Additional accomplishments include:

- A text in occupational safety and health engineering entitled, "Engineering Control of Workplace Hazards"
- A study by the Accreditation Board for Engineering and Technology (ABET) on the safety and health content of accredited academic programs in engineering
- A pilot speakers' bureau in engineering with presentations at six student chapters of engineering societies
- A teaching institute in occupational safety and health at the annual conference of the American Society of Engineering Education
- The manual for an advanced course in industrial hygiene engineering
- A series of seven engineering case studies
- A supplement for research grant programs, entitled "Engineering Control Systems Research"

**Schools of Business**

Project Minerva added several schools of business and faculty members to its active roles this year. The number of business schools now integrating occupational safety and health content into existing curricula has increased to 37. An estimated 2,500 prospective managers were enrolled in academic courses incorporating occupational safety and health topics, and over 100 faculty members in these schools took part in this instruction. A 2-day regional safety and health workshop was conducted at Eastern Illinois University for business faculty with 15 members attending from schools in 12 states. The latest developments in instructional resources include two new teaching modules, a book of readings from safety and health journals, management-oriented videotapes, and a faculty resource guide entitled, "Safety and Health Research Topics for Business Students." The annual Project Minerva Workshop was conducted in Chicago at the Academy of Management Meeting and brought

together representatives of industry, labor, government, and faculty from many Minerva business schools. Opportunities are being explored with publishers to include additional safety and health content in business texts.

**Training**

NIOSH conducts technical training courses for the Department of Health and Human Services, for other federal, state and local government agencies, and for the private sector, including occupational safety and health practitioners in industry, management, and labor unions.

During FY 1986, the Institute provided continuing education in occupational safety and health for over 15,000 students, including 26 courses for professional trainees. Special customized training courses were presented to health personnel at both the state and local level in New Jersey, Wisconsin, New York City, and Boston; to MSHA personnel at the MSHA training academy in West Virginia; and to health and safety personnel of the U.S. Army in Denver, and of the U.S. Navy in Pearl Harbor, Hawaii; and to the Food and Drug Administration in Cincinnati, Ohio. The Educational Resource Centers responded to NIOSH direction and provided over 310 continuing education courses for occupational health nurses, occupational physicians, industrial hygienists, and safety professionals and others responsible for worker safety and health.

Typical courses offered by NIOSH and/or the ERCs include Occupational Toxicology, Epidemiology of Occupational Injuries, NIOSH-Approved Spirometry Training, Annual Review and Update of Occupational Health Nurses, Industrial Hygiene Engineering, Industrial Ventilation, Sampling and Evaluating Airborne Asbestos Dust, Ergonomics and Occupational Safety, Health and Safety Training for Hazardous Waste Personnel, Occupational Respiratory Protection, Mini-Residency in Occupational Medicine for Physicians.

As in past years, the Institute evaluated training organizations that apply for approval to present courses under the Cotton Dust Standard in pulmonary function testing. It also responded to labor unions, state and local health agencies, and developmental academic programs at colleges and universities that requested consultation and training assistance.

**Curriculum Development**

Through its curriculum development activity, the Institute creates and revises courses and educational materials based on new research findings, technological advances, and the ever-changing job requirements of practitioners. Based on changes in published standards, NIOSH revised and updated several of its courses in FY 1986, including Sampling and Evaluating Airborne Asbestos Dust, Occupational Respiratory Protection, and Confined Workspaces. NIOSH revised a series of lecture modules reflecting the National Strategies for the first five of the Ten Leading Work-Related Diseases and Injuries; completed a preliminary evaluation of training needs for electric utility personnel; developed a videotape entitled "Mill Ventilation for Use in the Rubber Manufacturing Industry;" and continued revision of the training reference manual, "The Industrial Environment—Its Evaluation and Control," with the development of 26 more chapters. NIOSH continued to provide assistance to the CDC Laboratory Program Office in its evaluation and funding of an academic program to produce "director grade" personnel for health department laboratories. NIOSH collaborated with the Association of Teachers of Preventive Medicine to assist in revising the Directory of Educational Resources and Opportunities in Occupational Health and in developing new projects to stimulate incorporation of occupational safety and health into existing medical school curricula.

Training materials are distributed through the NIOSH clearinghouse, through the ERC network, in cooperation with the National Audiovisual Center, and through several other user-specific dissemination mechanisms.

**Policy Statements and Recommendations**

The Institute responds to the rulemaking efforts of regulatory agencies by providing critical evaluations of available research information and recommending controls for occupational safety and health hazards. In FY 1986, NIOSH completed written comments for seven rules proposed by the Department of Labor (DOL): benzene, formaldehyde, hazard communications, radon daughters, 1,3-butadiene, air quality standards, and methylenedianiline (MDA) and testified at DOL hearings for regulation of benzene, formaldehyde, and MDA. Completed documents included a Criteria Document on Occupational Exposure to Hot Environments; Current Intelligence Bulletins on Polychlorinated Biphenyls, Methylene Chloride, and 4,4'-Methylenedianiline; Alerts related to Confined Spaces, Grain Auger Electrocutions, and Fatalities Due to Oxygen-Limiting Silos; a white paper on Diesel Exhausts; and the 1986 editions of both the NIOSH Recommendations for Occupational Safety and Health Hazards and the NIOSH Current Intelligence Bulletins Summaries. Critical reviews were completed on the Carcinogen Policy, Dermal vs. Ingestion Toxicity Comparison, and Methods for Identifying Emerging Occupational Safety and Health Problems. Recommendations were made for

31 new documents to cover hazards of current importance.

**Dissemination of Information**

The Institute provides technical information and current awareness in occupational safety and health to its own personnel and the general public. It does this through statistical and consultation services and library and information sources. Databases developed by NIOSH provide access not only to NIOSH research activities but to occupational safety and health information from all over the world. The Institute's bibliographic database, NIOSHTIC, is available for on-line search through several private sources, and work is under way to make both NIOSHTIC and RTECS available on CD-ROM for use on personal computers. The number of entries in NIOSHTIC was increased to approximately 134,500, and more than 3,500 citations on hazardous waste alone were added to the database. Approximately 4,200 requests for technical information were completed in the fiscal year to such clients as the NIOSH staff, other governmental agencies, industry, labor organizations, OSHA staff, and the general public.

The Institute prints and distributes its own publications to convey the results of NIOSH research and investigations into occupational health problems and the means for controlling them. Almost 30,000 requests for publications were received and filled this year, and NIOSH is cooperating with Labour Canada and the American Conference of Governmental Industrial Hygienists to republish NIOSH documents for wider distribution.

Drafts were completed of 30 new guidelines for handling chemical hazards. These are currently under technical review and when approved will be published in a set of 65 Occupational Health Guidelines for Chemical Hazards for use by regulatory agencies, industry, labor, ERCs, and others. The master file of the *Registry of Toxic Effects of Chemical Substances* (RTECS) was expanded and now includes 84,000 substances. Quarterly microfiche computer tapes and the annual book form of RTECS were produced, and a tape of this file was provided for use with the MEDLARS on-line system. A subfile of RTECS substances important to regulatory agencies was also completed.

**NIOSH Manual of Analytical Methods**

NIOSH is continually developing and revising analytical methods for determining toxic substances. This year 50 revised methods were prepared in camera-ready form for inclusion in the second supplement to the *NIOSH Manual of Analytical Methods*. The third edition of the *Manual*, which was published in FY 1985, contains analytic methods for approximately 300 toxic substances that cause such problems as occupational lung disease (e.g., asbestos, pneumoconiosis, and silicosis), cancers, neurotoxic illness, and dermatologic conditions. Several of these NIOSH methods have been incorporated into Draft International Standards by working groups of the International Standards Organization Technical Committee 146 (Air Quality), with experts from Canada, Federal Republic of Germany, France, and Great Britain.

# Publications

To further disseminate results of their research, Institute scientists publish articles in scientific journals and other periodicals of occupational interest. Articles submitted to scientific journals undergo a strict system of peer review before being accepted for publication. The following articles and publications appeared in FY 1986 (October 1, 1985–September 30, 1986) as a result of NIOSH scientific activities.

Abrons HL, Sanderson WT, Petersen MR. Respiratory Effects of Portland Cement Dust. Cincinnati, OH: NIOSH Report, 1986

Adams J, Buelke-Sam J, Kimmel CA, et al. Collaborative Behavioral Teratology Study: Protocol Design and Testing Procedures. Neurobehav Toxicol Teratol 1985;7(6): 579–86.

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AMERICAN INDUSTRIAL HYGIENE ASSOCIATION

Central Virginia Local Section



February 10, 1988

Mr. Heinz Ahlers
DHHS
Public Health Services
CDC
NIOSH
4676 Columbia Parkway
Cincinnati, OH 45226

Dear Ahlers,

Thank you very much for agreeing to speak at our dinner meeting on March 17, 1988. As I related to you over the phone, we are primarily interested in a presentation on the criteria NIOSH uses in selecting chemicals for study and an update on NIOSH activities.

Our meeting agenda is usually 5:30 - 6:30, Cocktails; 6:30 - 7:15, Dinner; and 7:15 - 8:00, Speaker Presentation. Our section membership is comprised of occupational health specialists, predominantly Industrial Hygienists. If there is anything I can do for you as advance preparation, please give me a call (804) 775-5039).

I will be in contact as March 17th draws near.

Sincerely,

Bill Heese

William D. Heese, Jr.
President - Elect
Central Virginia Section
American I. H. Association

WDHjr/sjc